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TURBO

COURSE CENTER

FOUNDATION

TURBO

NO. Final revision (1)

4th CIVIL YEAR

المكتبة	أمام بوابة كلية الاداب مباشرة
الفرع الرئيسي	حي الزهور أمام النساجون الشرقيون
الفرع الثاني	حي الزهور أمام كوبري مستشفى الجامعة بجوار أنوار التوحيد

مراجعة (1)

June 2006:-

given:-

Column load = 1.8 MN

D = 35 cm

Qall = 450 kN

L = 6m

G.W.T at -3m from G.S

The Cap level at -2m from G.S

- Soil shear strength = 15 kpa
- ultimate soil bearing at Tip = 1000 kpa

elev (m)	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	end
Soil	Fill			loose sand $\phi = 27°$ $\gamma_{sat} = 17.5$ $\gamma_b = 18$				Med. dense $\phi = 31°$ $\gamma = 19$ kN/m³				Med. clay $\gamma_{sat} = 19$ kN/m³			Sand $\gamma = 19.5$	

Req.: determine group efficiency.

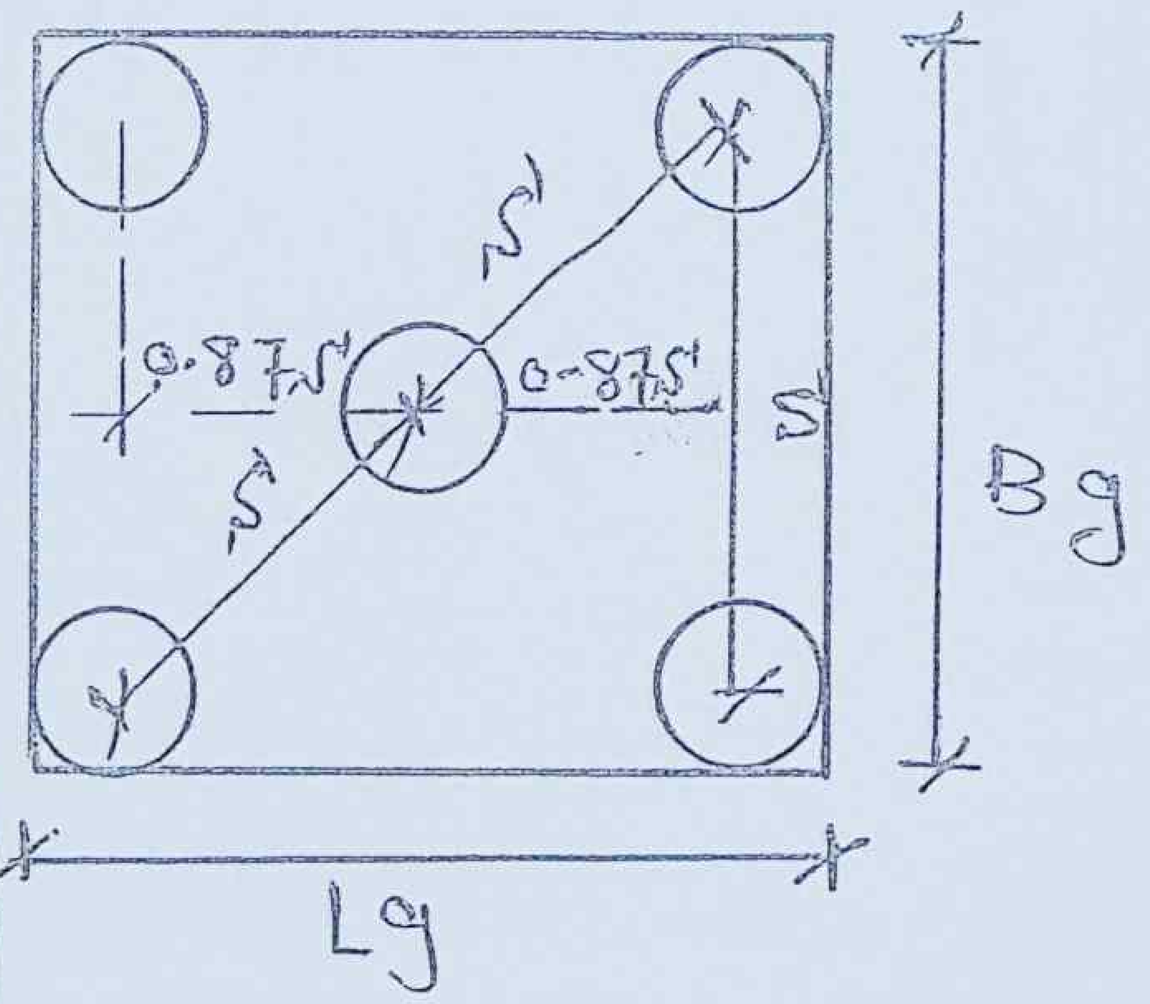
Sol.:-

$$\text{No. of piles} = \frac{1.1 \times P_{col}}{Q_{all}}$$

No. of piles $= \frac{1.1 \times 1800}{450} = 5$ piles.

Take S (2.5 – 8)d

$S = (0.875 \rightarrow 2.8\text{ m})$



∴ Take $S = 1.0$ m

∴ $L_g = 2 \times 0.87 \times 1.0 + 0.35 = 2.10$ m

$B_g = 1.0 + 0.35 = 1.35$ m

$$\eta = \frac{Q_{ult\,g}}{\Sigma Q_{ult}}$$

$$Q_{ult\,g} = q_{ult} A_b + S' A_s - \gamma' A L$$

(bearing) (Friction) (Wp)

في هذه المسألة نعطى قيمة (qult) كلها وهى المعطاة ب ←

ultimate soil bearing at Tip = 1000 kpa

$A_b = 2.10 \times 1.35 = 2.84\text{ m}^2$

المحيط Per. $= m_g = 2 \times (1.35 + 2.10) = 6.9$ m

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ـــ في هذه المسألة معطى ايضاً للتصحيح قيمة (C) وهي المقصودة بـ

Soil shear strength = 15 Kpa.

$A_s = Per. \times L = 6.9 \times 6 = 41.4\ m$

$\therefore Q_{allg} = 1000 \times 2.84 + 15 \times 41.4 - 2.84(18 \times 1 + 7 \times 3 + 9 \times 2) =$

$= \underline{3299.12}\ kN$

$Q_{ult} = F.S \times Q_{all} = 3 \times 450 = 1350\ kN$

$\therefore \eta = \dfrac{3299.12}{5 \times 1350} = 0.49$

$\therefore 0.49 \times 450 \times 5 = 1102.5 < 1.1 \times P_{col} = 1980$

وبالتالي للتحسين الآتي:-

١- زيادة المسافة بين الخوازيق.

٢- زيادة سعة الخازوق بزيادة قطره او طوله.

٣- زيادة عدد الخوازيق.

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← في هذه المسألة معطى ارضية التصميم قيمة (ك) وهي المقصودة بـ
Soil shear strength = 15 kpa.

$A_s = Per. \times L = 6.9 \times 6 = 41.4\ m$

$\therefore Q_{ult} = 1000 \times 2.84 + 15 \times 41.4 - 2.84 (18 \times 1 + 7 \times 3 + 9 \times 2) =$

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$\therefore 0.49 \times 450 \times 5 = 1102.5 < 1.1 \times P_{col} = 1980$

<u>وبالتالي لابد من الاتي:</u>

١- زيادة المسافة بين الخوازيق.

٢- زيادة سعة الخازوق بزيادة قطره او طوله.

٣- زيادة عدد الخوازيق.

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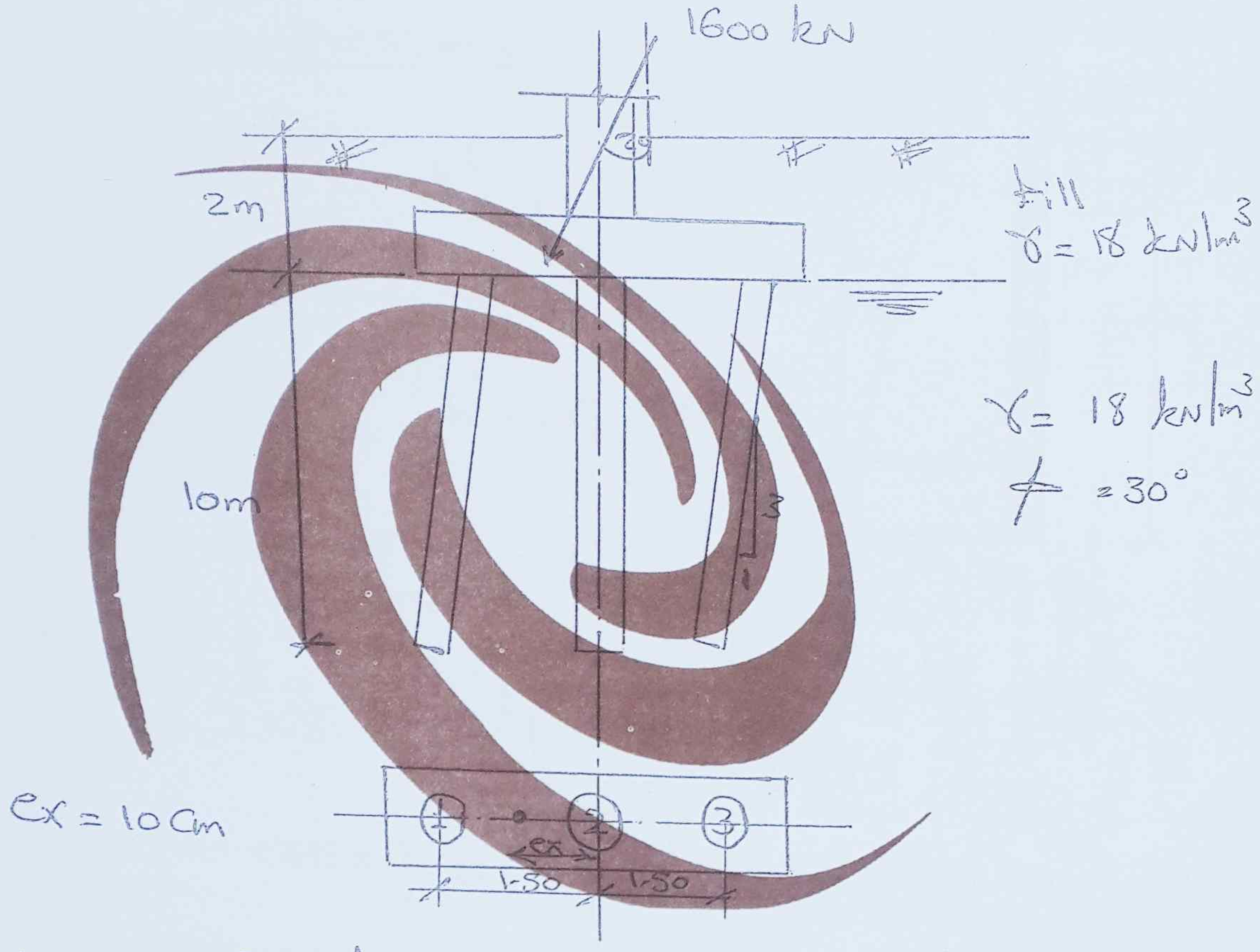
Examples:



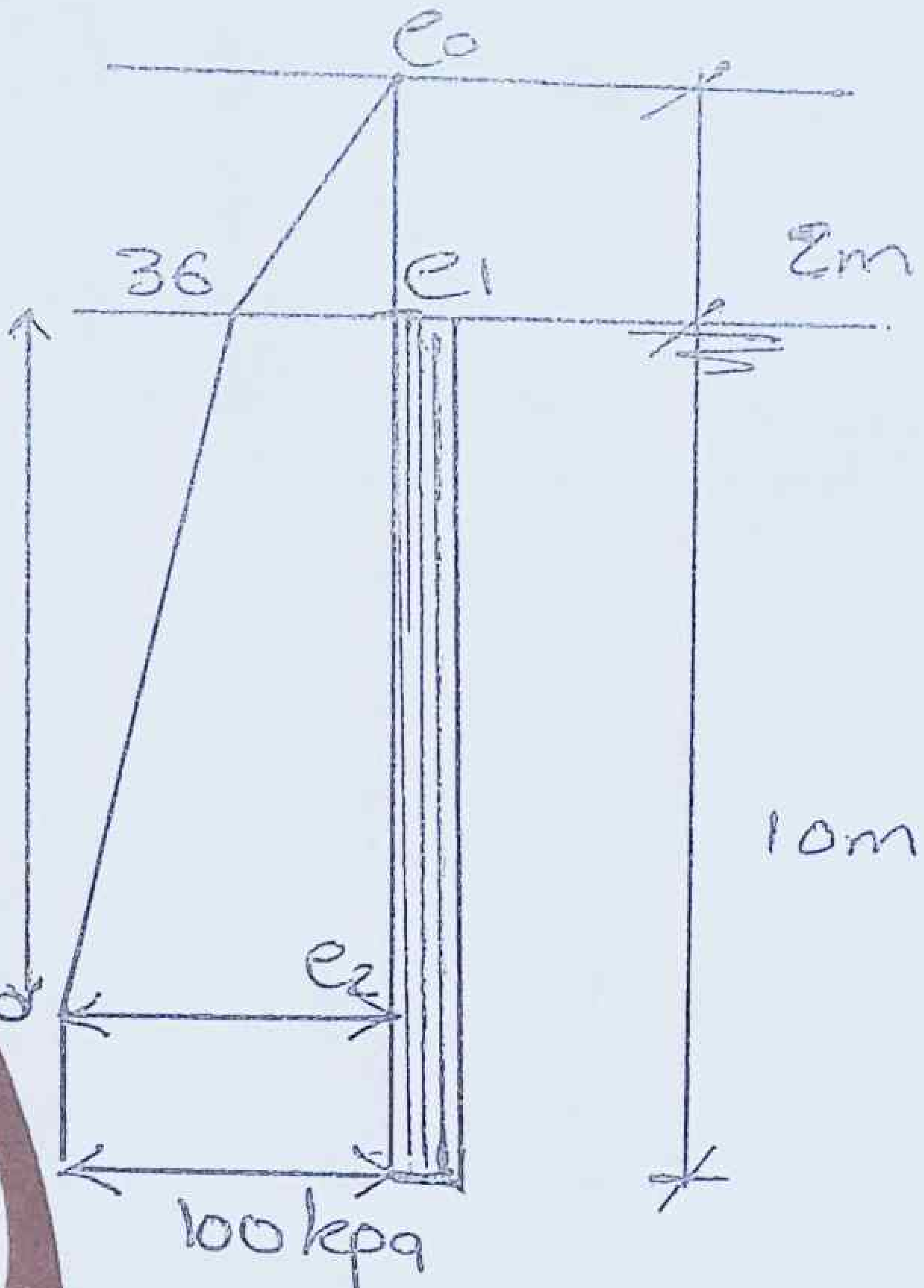
40 Cm Concrete driven Piles.

Req:
1- Single pile Capacity in Compression and tension.
2- pile loading.
3- horizontal pile Capacity.

→ **Solution:-**

I) Single pile Capacity :-

A) Compression :-



$Q_{ult} = Q_b + Q_F$

$= \sigma'_p N_q A_b +$

$\sum k_{hc}\, m \tan\delta\, \sigma_z \Delta z$

$L_{cr} = 20 * 0.4 = 8m$

$e_1 = 2 \times 18 = 36$ kpa

$e_2 = 36 + 8 * 8 = 100$ kpa

$\phi' = \frac{30+40}{2} = 35^{\circ}$

$N_q = 75$

$Q_{ult} = \left[100 \times 75 \times \frac{\pi}{4}(0.4)^2\right] + \left[1.25 \times \pi \times 0.4 \times \tan(3/4 \times 30) * \left(\frac{36+100}{2} \times 8 + 100 \times 2\right)\right] = 1426 \text{ kN}$

$Q_{all} = \frac{1426}{3.0} = \underline{475 \text{ kN}}$

B) Tension :-

$T_{ult} = Q_F + W_p$

$= \sum k_{ht}\, m \tan\delta\, \sigma_z \Delta z + W_p$

$= \left[0.8 * \pi * 0.4 \times \tan\left(\frac{3}{4} \times 30\right) * \left(\frac{36+100}{2} \times 8 + 100 \times 2\right)\right]$

$+ \left[\frac{\pi}{4}(0.4)^2 * 10 * 25\right] = 309.8 + 31.4$

$T_{all} = \frac{309.8}{3} + 31.4 = \underline{108.85 \text{ kN}}$

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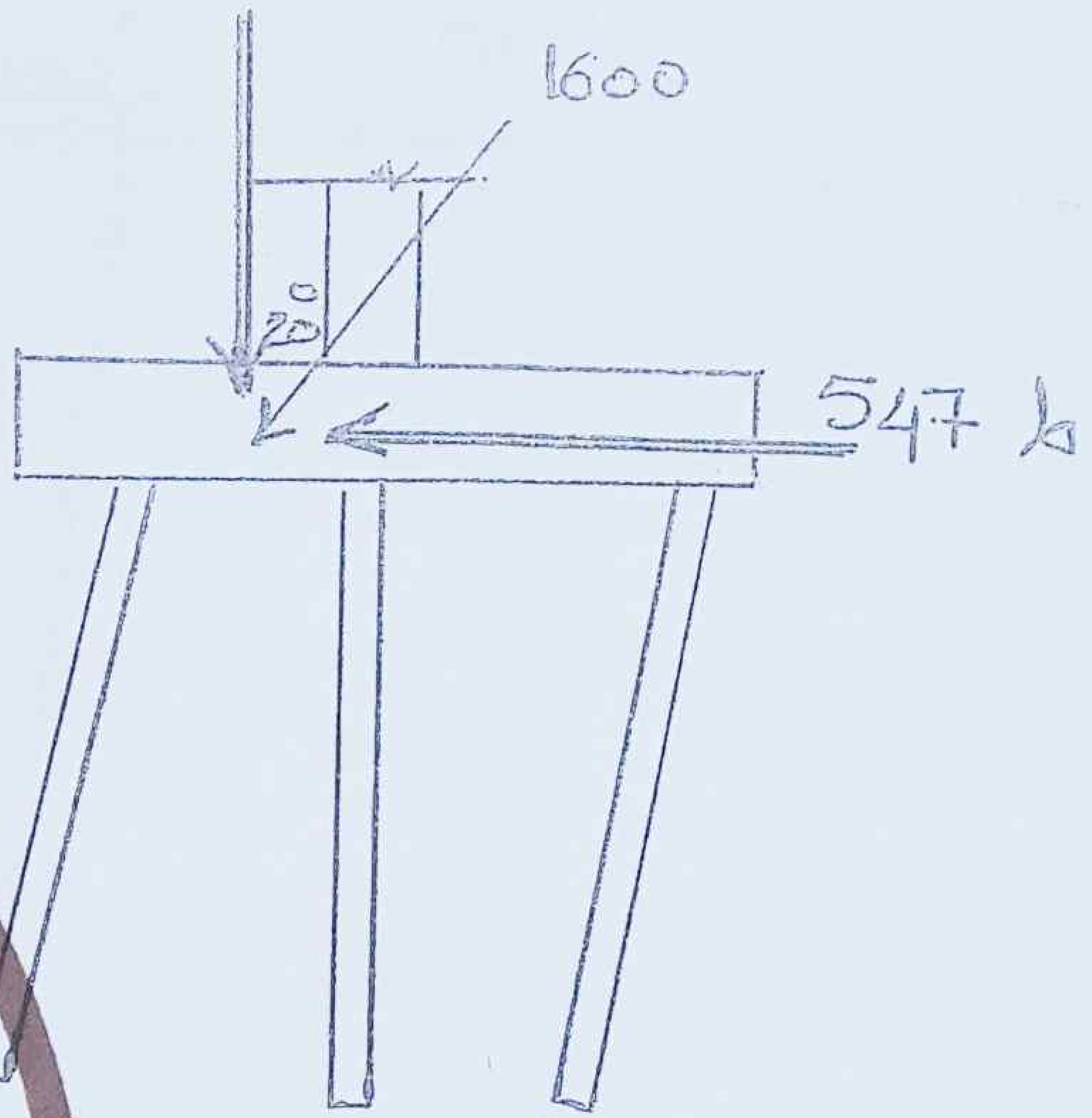
2 Pile loading :-

$1600 \cos 20^\circ = 1503.5\ kN$



$$P_v = \frac{V}{N} + \frac{V \cdot e_x \cdot x}{\Sigma x^2}$$

$$V = \frac{1503.5}{3} + \frac{1503.5(-0.1)x}{2 \times 1.5^2}$$

$$= 501.1 - 33.4x$$

verticle loads :-

$$P_{v_1} = 501.1 - 33.4(-1.50) = 551.2\ kN$$

$$P_{v_2} = 501.1\ kN$$

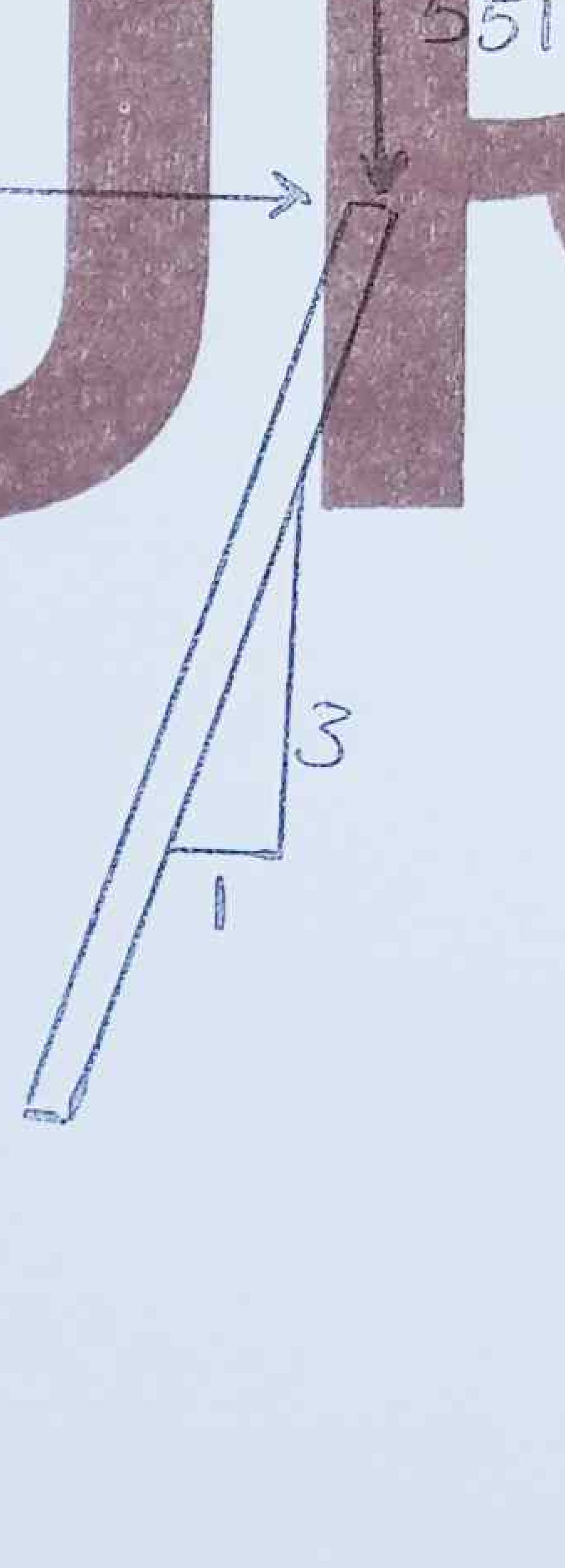
$$P_{v_3} = 501.1 - 33.4 \times 1.50 = 451\ kN$$

horizontal loads :-

* فى حالة الخوازيق المائلة عند تحليل القوة الرأسية عليها سينتج عليها قوة أفقية أخرى

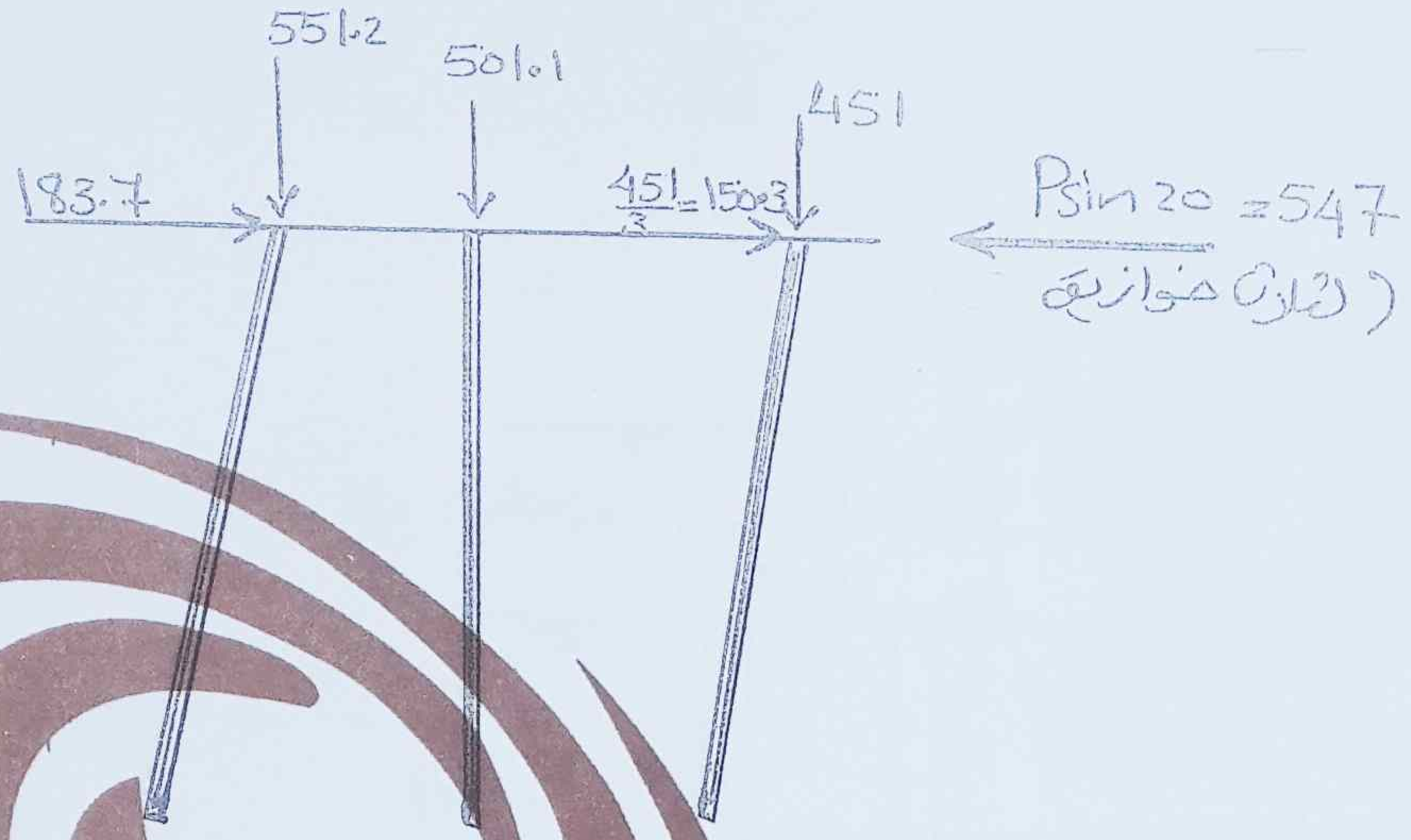
$183.7 = \frac{551}{3}$

(ناتجة من تحليل القوة الرأسية)



* نلاحظ ان هذه القوة عكس إتجاه $(P \sin 20^\circ)$

* وبالتالى فإن الخوازيق تتحمل فرق القوتين كالآتى :-



$$\Delta H = 547 - (150.3 + 183.7) = 213 \text{ kN}$$

يتم توزيعها على الخوازيق

$$\Delta H / \text{pile} = \frac{213}{3} = \underline{71 \text{ kN}}$$

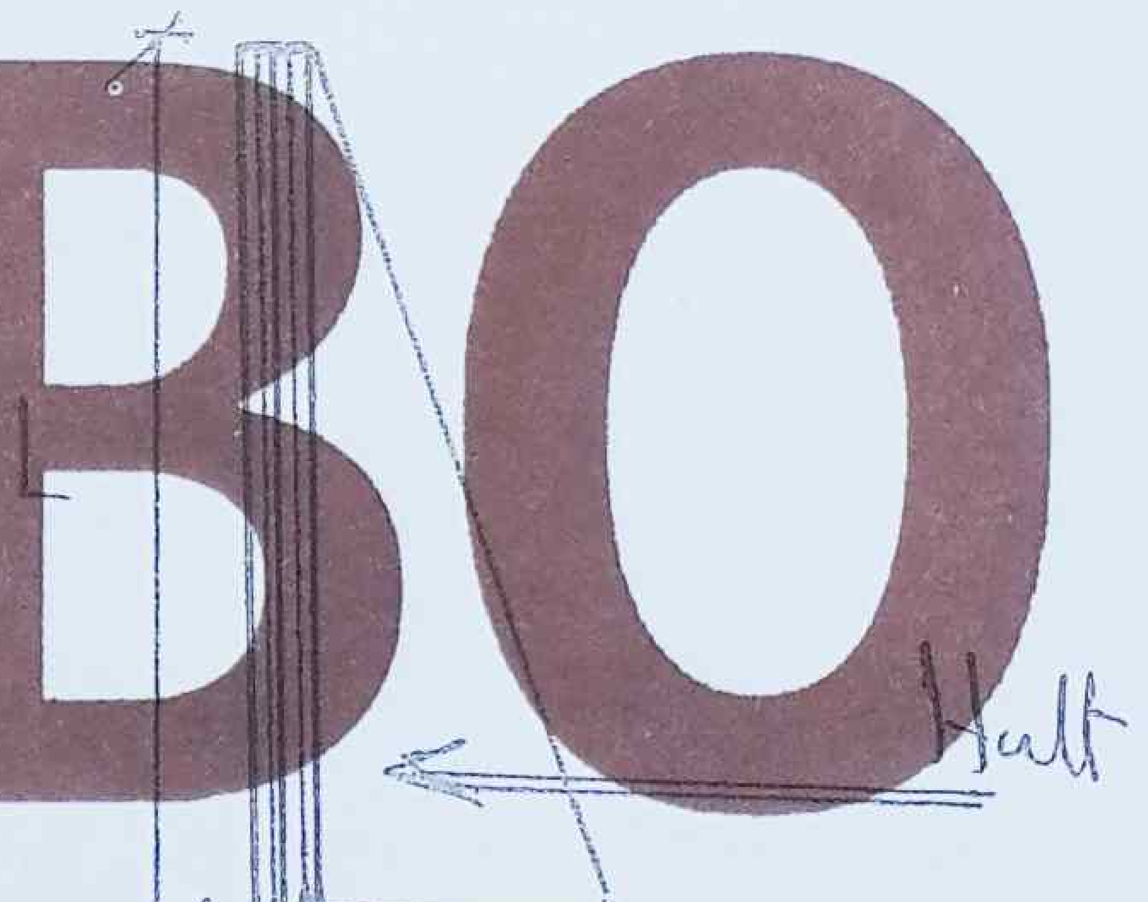
3] Horizontal pile Capacity:

بإهمال الردم

$$H_{ult} = \frac{1}{2}(3\gamma' D L\, k_p) \times L$$

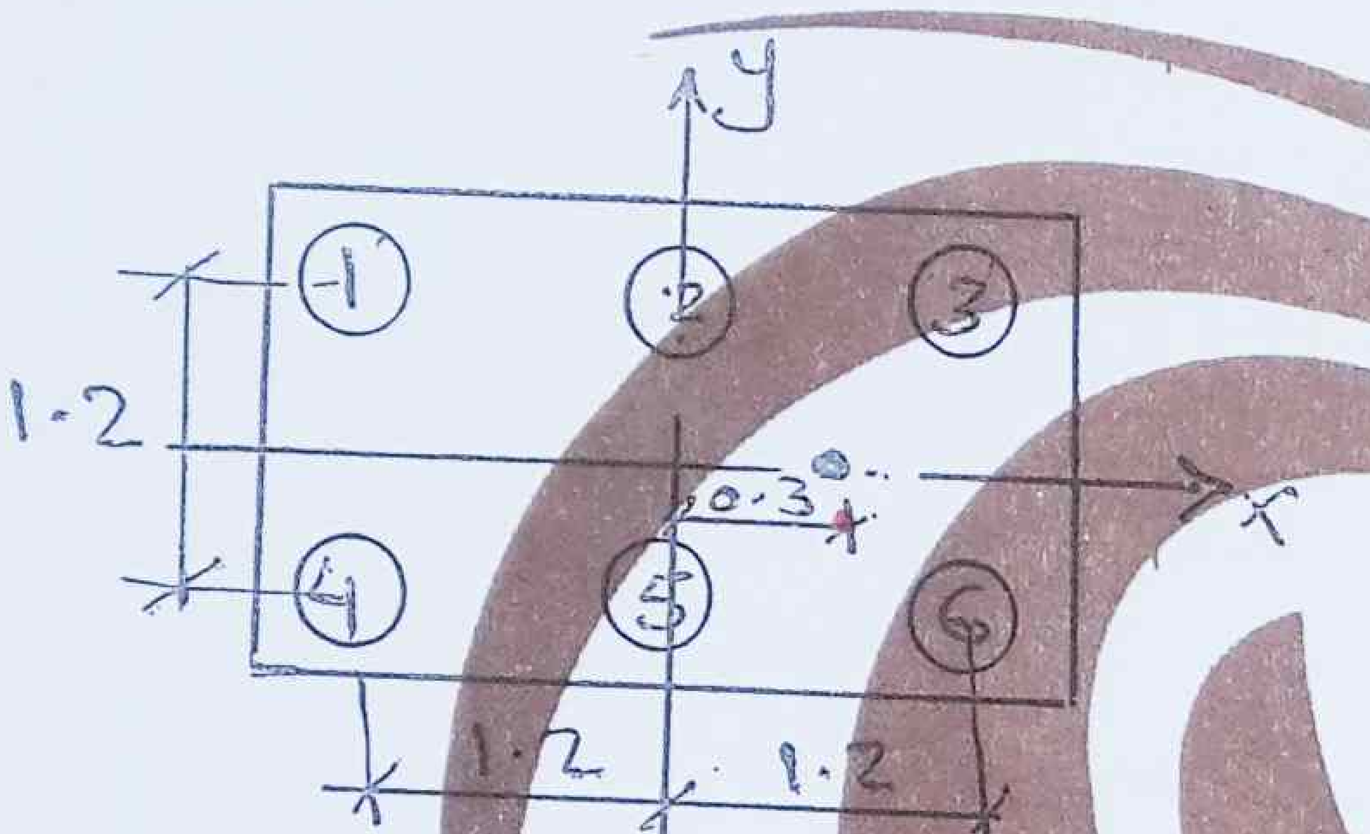
$$= 1.5 \times (18 - 10) \times 0.4 \times 10^2 \times 3$$

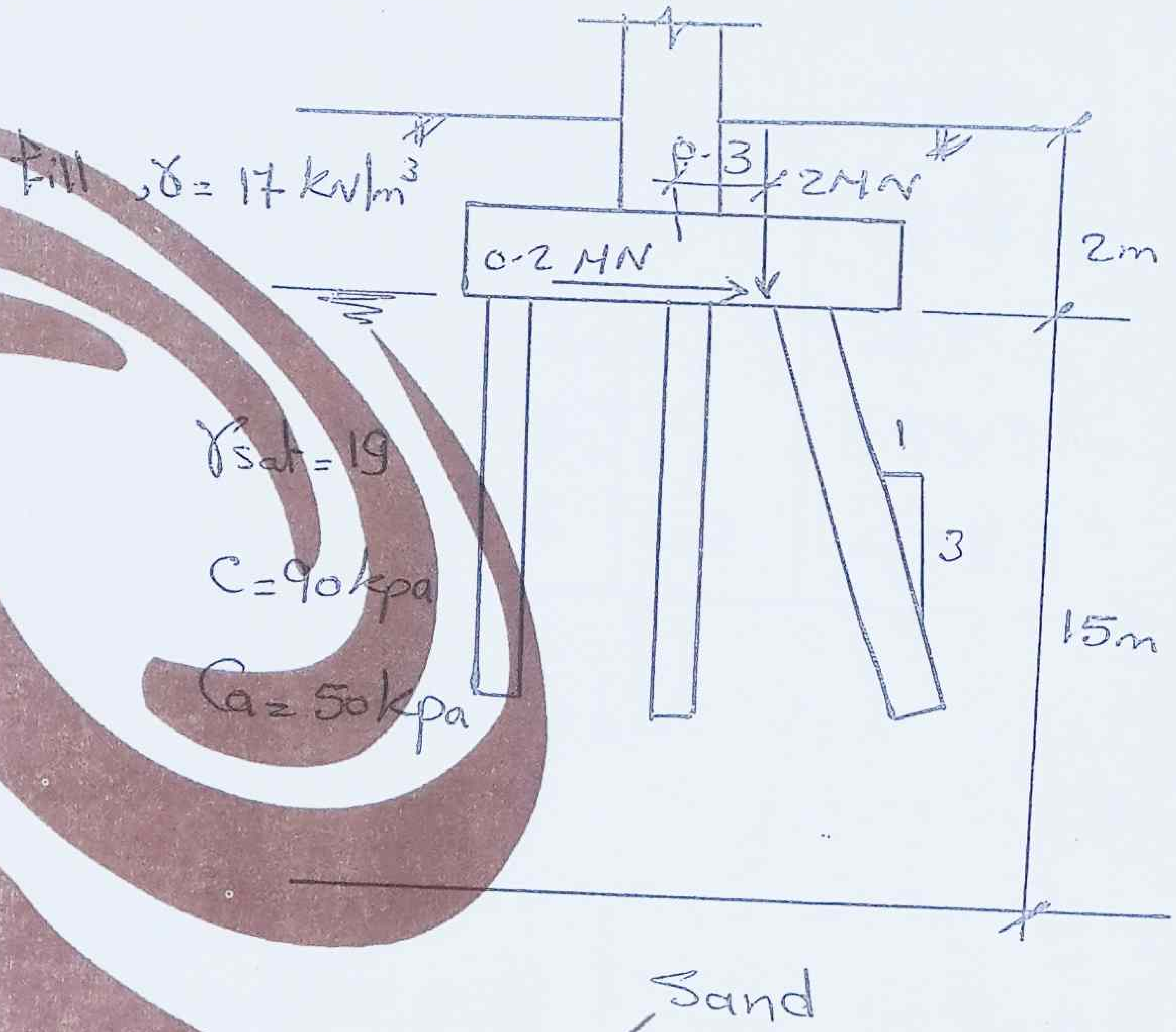
$$= 1440 \text{ kN} > 71 \text{ kN}$$



$$k_p = \frac{1 + \sin 30}{1 - \sin 30} = 3.0$$

October 2006 :-





50 cm Square Precast driven pile.

Req :- - load on each pile.

- pile length.

SoL :-

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1- $P_v = \frac{V}{n} + \frac{V \cdot e_x \cdot X}{\sum x^2} + \frac{V \cdot e_y \cdot y}{\sum y^2}$

$e_x = 0.3$, $e_y = 0$

$\therefore P_v = \frac{2000}{6} + \frac{2000 * 0.3\ X}{\sum x^2}$

$\sum x^2 = x_1^2 + x_2^2 + \text{----}\ x_6^2$

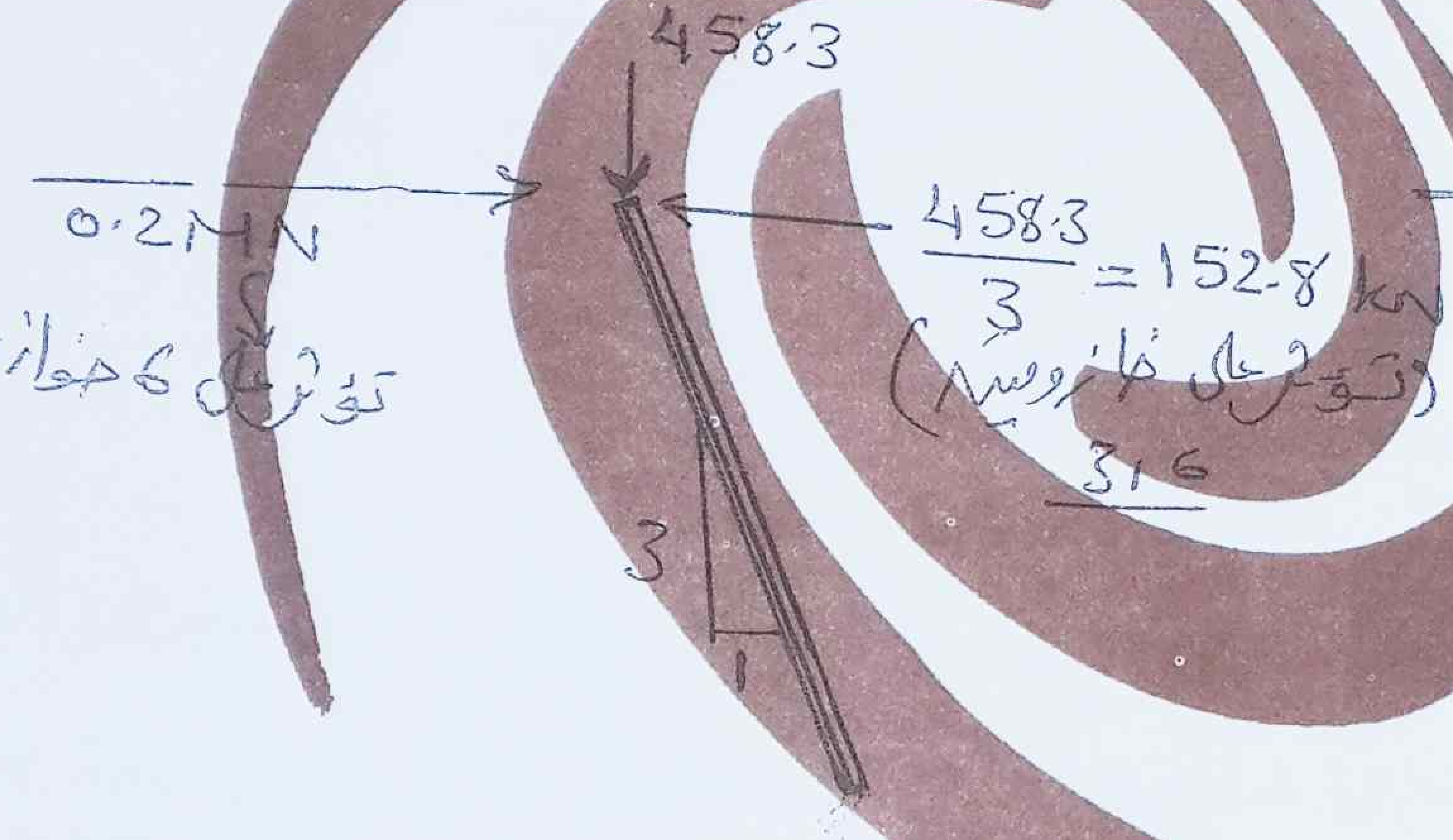
$= 4 \times (1.2)^2 = 5.76$

$P_v = 333.3 + 104.17\,X$

Pile	X	Pv
1	-1.2	208.3
2	0	333.3
→ 3	1.2	458.3
4	-1.2	208.3
5	0	333.3
→ 6	1.2	458.3

For Hl. loading:-

3 , 6 الخوازيق المائلة



$\therefore \underline{P_{h_3}} = P_{h_6} = \underline{152.8}$

$\Delta H = 0.2 * 1000 - 2 \times 152.8 = 1694.5$ kN

$\Delta H / \text{pile} = \frac{1694.5}{6} = 282.4$ kN

[2] **pile lengths:-**

$Q_{ult} = Q_b + Q_F = C N_c A_b + C_a A_s$

$Q_{all} \geq P_v$ و لكي تكون الخوازيق (safe) آمنة

$\therefore Q_{all} = \frac{Q_{ult}}{3} = \frac{1}{3}\left(C N_c A_b + C_a A_s\right)$

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Take $Q_{all} = P_v$

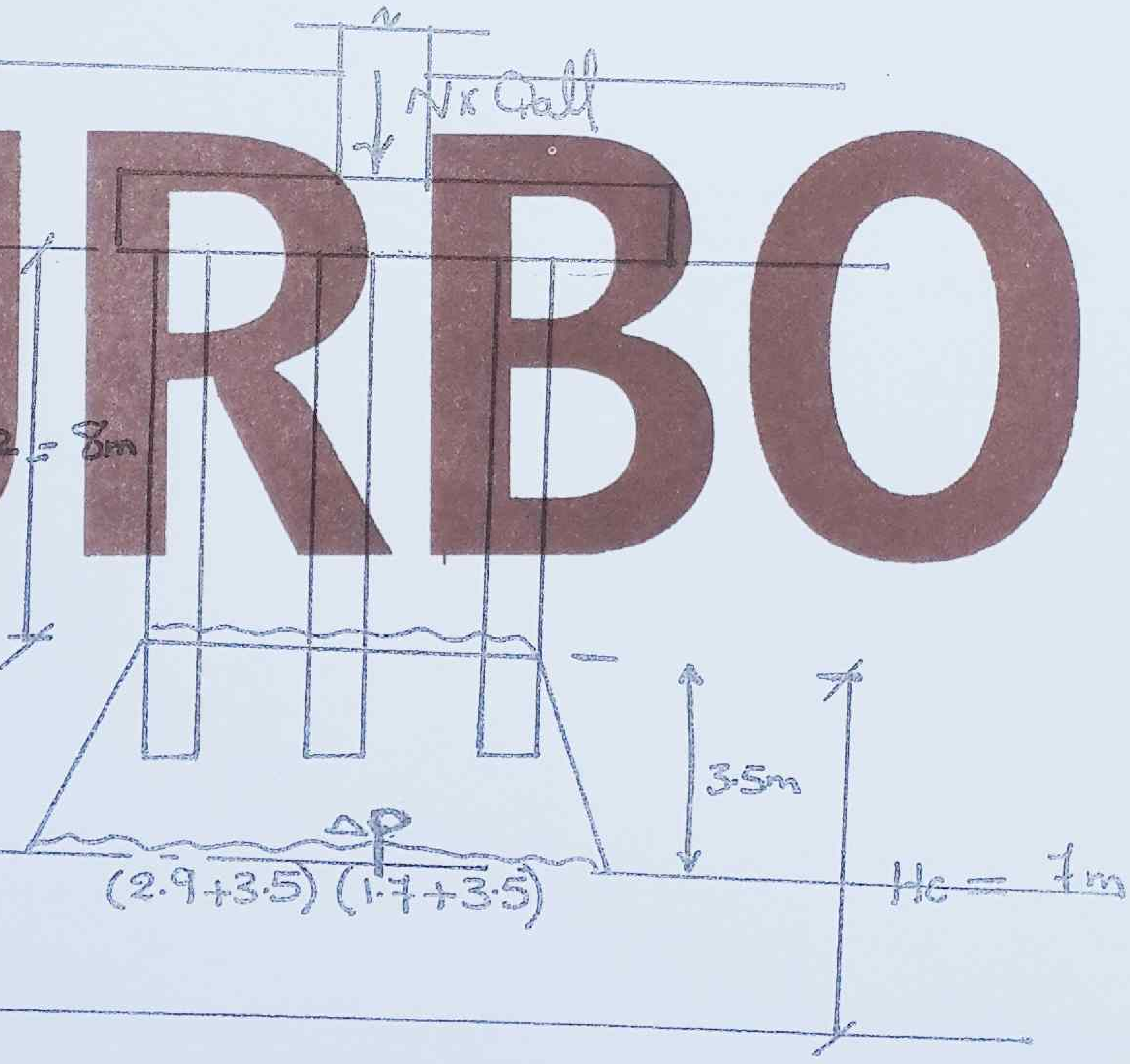
$$458.3 = \frac{1}{3}\left(90 \times 9 \times 0.5^2 + 50 \times (\overset{\text{للمحيط}}{4 \times 0.5}) \times L\right)$$

$\therefore$ $L = 11.724m$

Take $\underline{\underline{L = 12m}}$

* اذا كان معطى قيمة $m_v = 1 \times 10^{-5} m^2/kN$ للتربة وبفرض انه خوازيق احتكاك والمطلوب حساب الهبوط . (ignor inclination) للتسهيل

$\delta = m_v \ \Delta p \ H_c$



* $L_g = 2 \times 1.2 + 0.5$
$= 2.9m$

* $B_g = 1.2 + 0.5$
$= 1.7 \ m$

* $\Delta p = \dfrac{6 \times 458.3}{(1.7+3.5)(2.9+3.5)}$

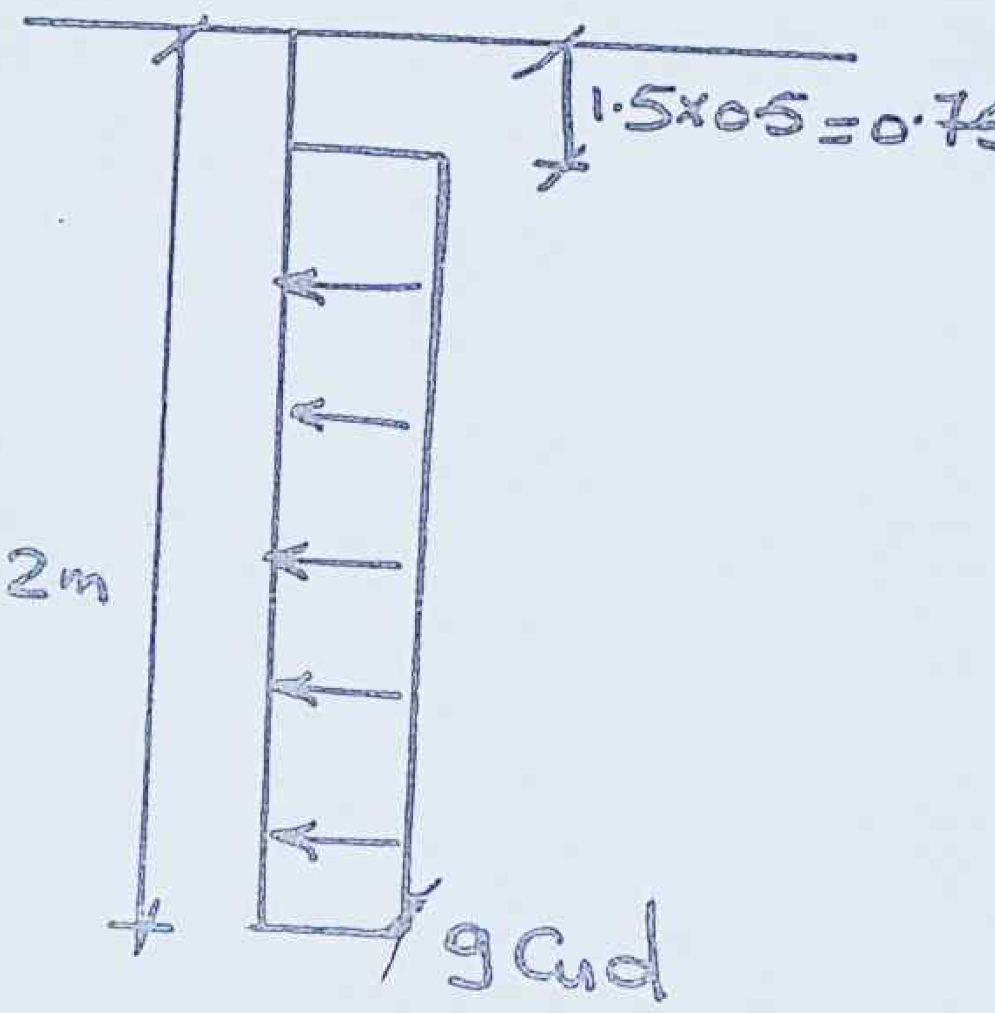
$= 82.6 \ kpa$

$\therefore \delta = 1 \times 10^{-5} \times 82.6 \times 7 = 0.0057$

$= 0.57 \text{ cm}$

* إذا اردنا حساب مقاومة الخازوق الأفقية Hult

$H_{ult} = 9 C_u d (L - 1.5d)$



$= 9 \times 90 \times 0.5 (12 - 0.75)$

$= 4556 \text{ kN} \neq H/\text{pile}$

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May (2001):-

given:-

Column load = 1.2 MN

Q_{all} = 350 kN

L (pile length) = 9 m

S' = 12.5 kpa

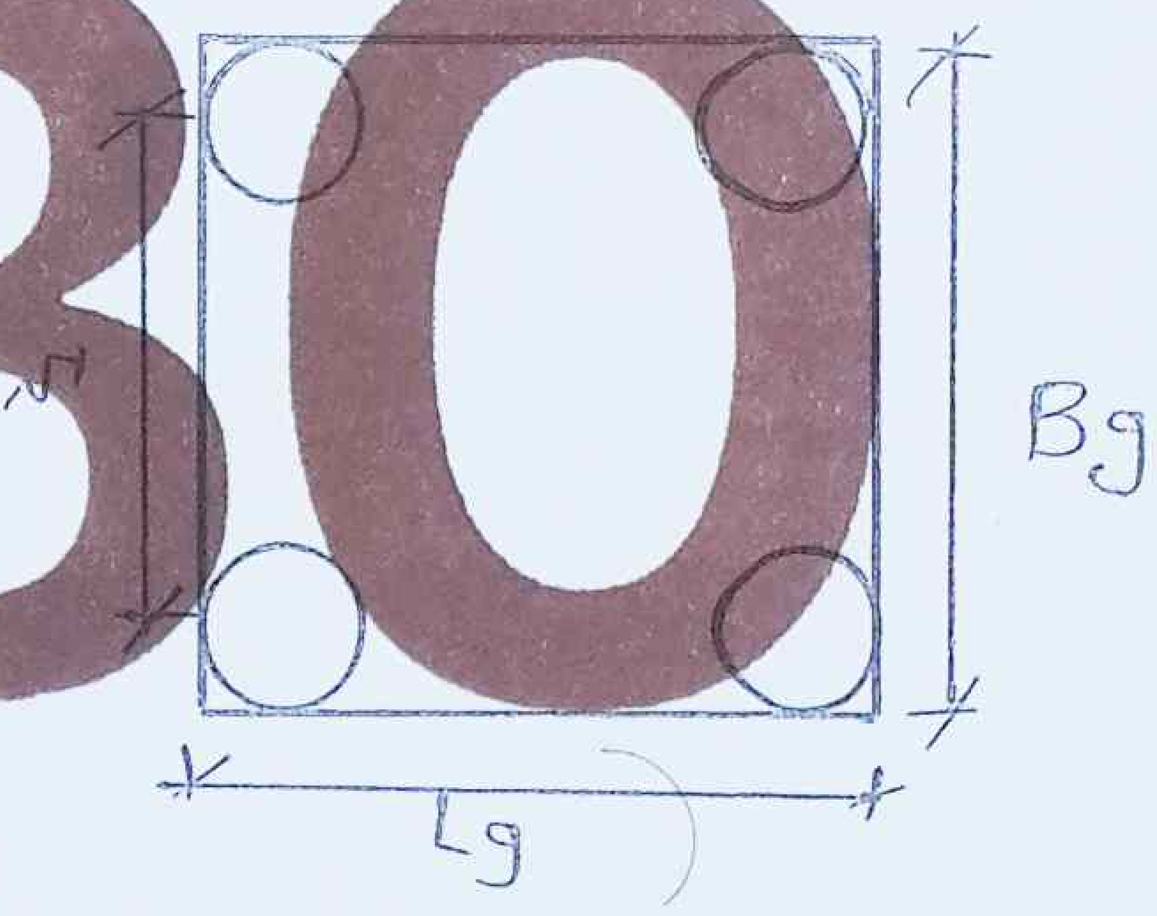
q_{ult} = 1000 kpa

Req: Group efficiency.

Sol.:

No. of piles = $\frac{1.1 \times 1200}{350}$ = 4 piles

assume D = 0.5 m (pile dia.)



S = (2.5 - 8) d

= 1.5 m

Lg = Bg = 1.5 + 0.5 = 2.0 m

$$\eta = \frac{Q_{ult\,g}}{\sum Q_{ult}}$$

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$Q_{ult\,g} = q_{ult}\,A_b + f_s\,A_s - \gamma'\,A\,L$

$= 1000 \times (2)^2 + 12.5 \times (4 \times 2 \times 9) - 18 \times (2)^2 \times 9$

$= 4252$ kN

$\gamma' = 18$ kN/m^3 تم فرض الكثافة

$\eta = \dfrac{4252}{4 \times 350 \times (3)} \approx 1.0$

Qult. معامل امان للتحويل

$1.0 \times 350 \times 4 > 1.1 \times 1200.$

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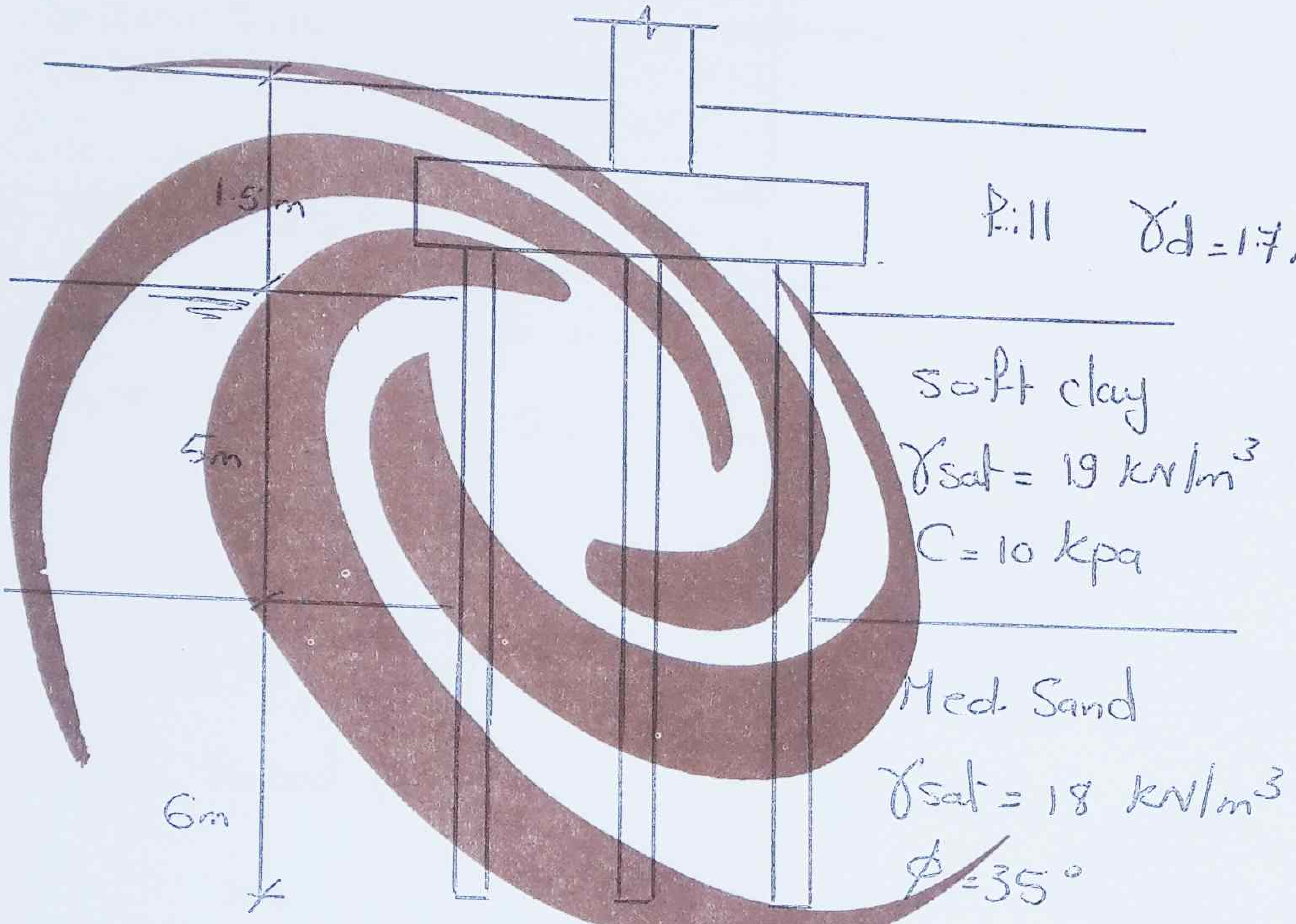
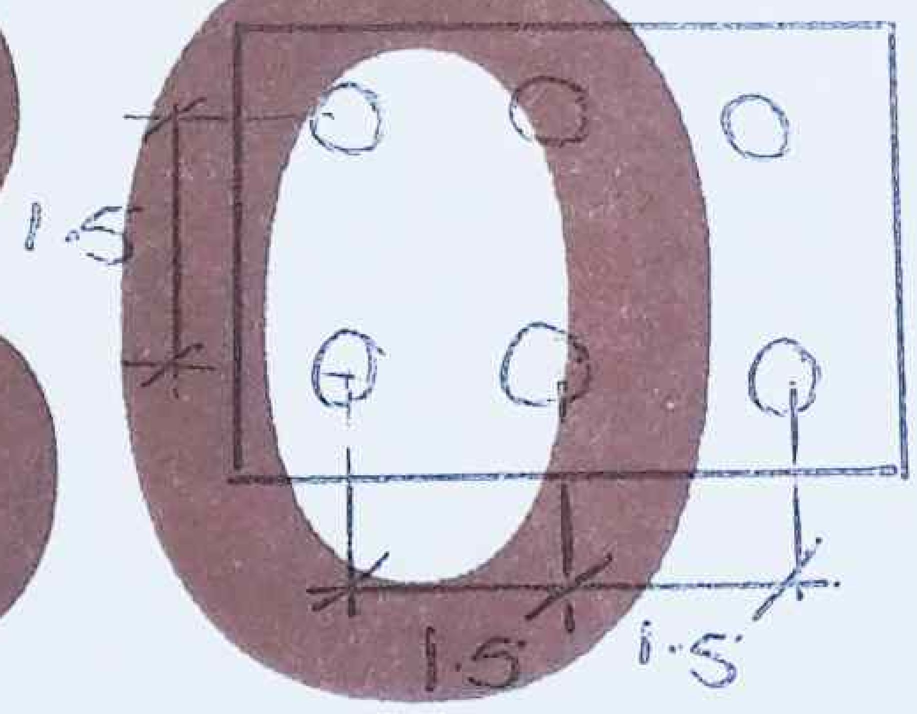
May 2004 :-



Req. :- Safe column load for group of 6 piles with 0.5 m diameter.



SoL. :- $\Sigma Q_{all} \geq 1.1 \times P_{col}$

Pile Capacity :-

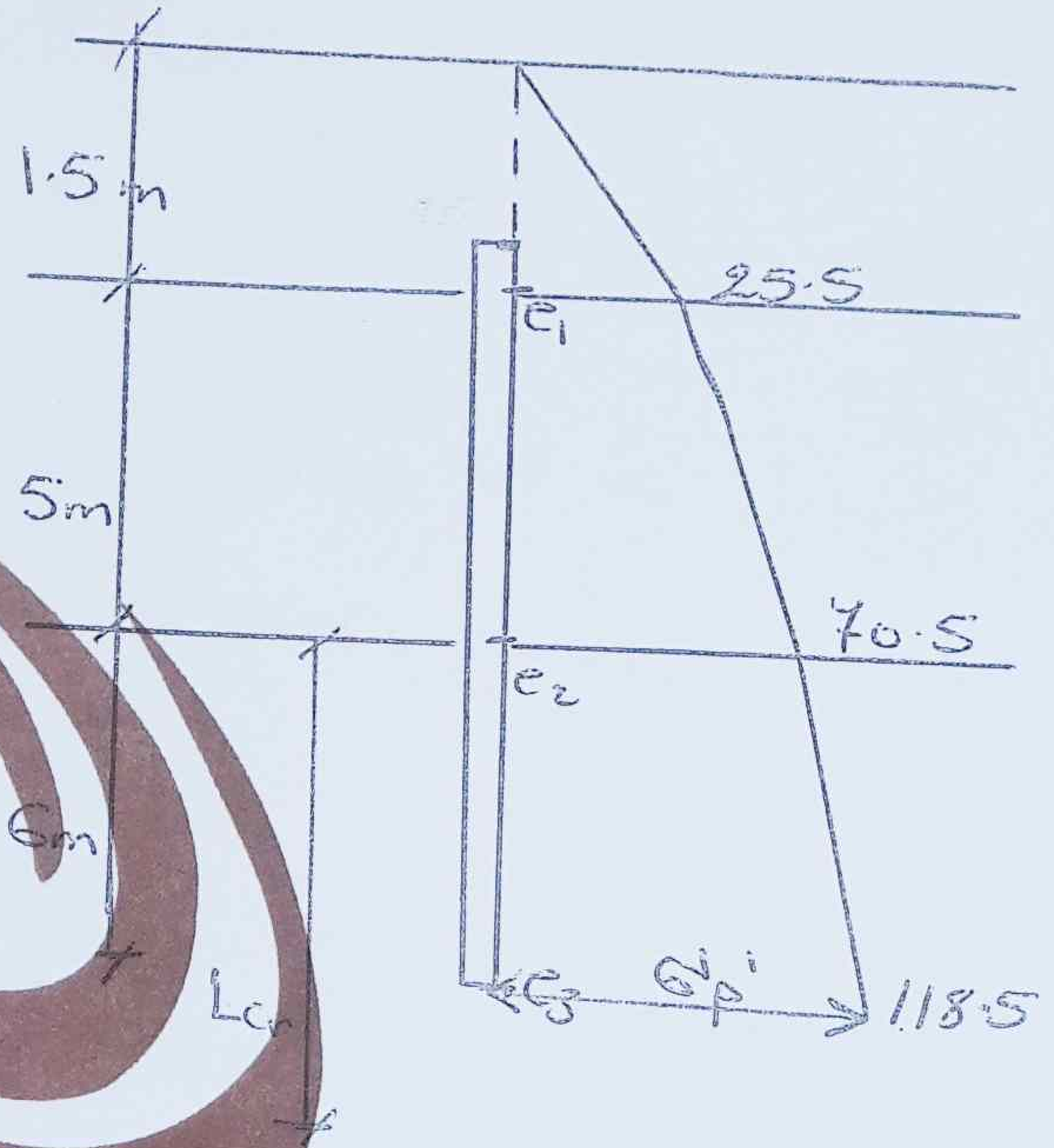
$$Q_{ult} = Q_b + Q_F$$

[I] **bearing resistance** :-

$$Q_b = \sigma_p' \times N_q \times A_b$$

$L_{cr} = 20 \times d$

$= 20 \times 0.5 = 10\,m$



$e_1 = 17 \times 1.5 = 25.5\ kN/m^2/m'$

$e_2 = 25.5 + 9 \times 5 = 70.5$ "

$e_3 = 70.5 + 6 \times 8 = 118.5$ "

For bored piles $\phi' = \phi - 3 = 35 - 3 = 32°$

ϕ'	N_q
30	30
32	→ (48)
35	75

(5) (45)

$\therefore N_q = 48$

$\therefore Q_b = 118.5 * 48 \times \frac{\pi}{4}(0.5)^2 = 1047\,kN$

[2] Friction resistance:-

$Q_F = \sum k_{hc}\ m \tan\delta\ \sigma'_z \Delta z$

طبقة الردم و طبقة الطين (very soft clay) يتم إهمال الاحتكاك لديهم

$$Q_F = 1.25 \times \pi \times 0.5 \times \tan\left(\frac{3}{4} \times 35\right) \times \left(\frac{70.5 + 118.5}{2}\right) \times 6$$

$$= 549 \text{ kN}$$

$$\therefore Q_{ult} = 549 + 1047 = 1596 \text{ kN}$$

$$Q_{all} = 1596/3.0 = 532 \text{ kN}$$

<u>Pile as short Column:-</u>

$$P_u = 0.35 f_{cu} A_c + 0.67 f_y A_{sl}$$

$$= 0.35 \times 25 \times \frac{\pi}{4}(0.5)^2 + 0.67 \times 360 \times \frac{0.8}{100} \times \frac{\pi}{4}(0.5)^2$$

$$= 2.10 \text{ MN} = 2100 \text{ kN}$$

$$P_{all} = \frac{2100}{1.75} = 1200 \text{ kN}$$

$$\therefore Q_{all} = 532 \text{ kN}$$

$$\Sigma Q_{all} = 6 \times 532 = 3192 \text{ kN}$$

$\therefore$ Safe Column load = 3192 kN

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* How to increase the safety factor :-

١- زيادة قدرة تحمل الخازوق بزيادة طوله او قطره.

٢- إستخدام خوازيق (pipe piles) مواسير مفتوحة وصب خرسانة بداخلها مما يؤدى إلى زيادة نهاية الخازوق (base enlargement) مما يؤدى إلى مقاومة تأثير الشد.

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* **Example :-** Find pile capacity using Hiley's Method

given :- driving energy = 40 kN.m

$C = 2.7\ cm$, $S = 7\ mm$, $\eta = 0.4$

Sol :- $R_u = \dfrac{W \times h \times \eta}{S + \frac{C}{2}}$

* المقصود بـ driving Energy = طاقة المطرقة

$= W \times h$

$\therefore W \times h = 40\ kN.m$

للتحويل من kN.m لـ kN.mm

$$\therefore R_u = \frac{40 \times 1000 \times 0.4}{7 + \frac{27}{2}} = 780\ kN$$

$$\therefore R_{all} = \frac{780}{3.0} = 260\ kN$$

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Examples:-

40 cm Concrete driven piles.

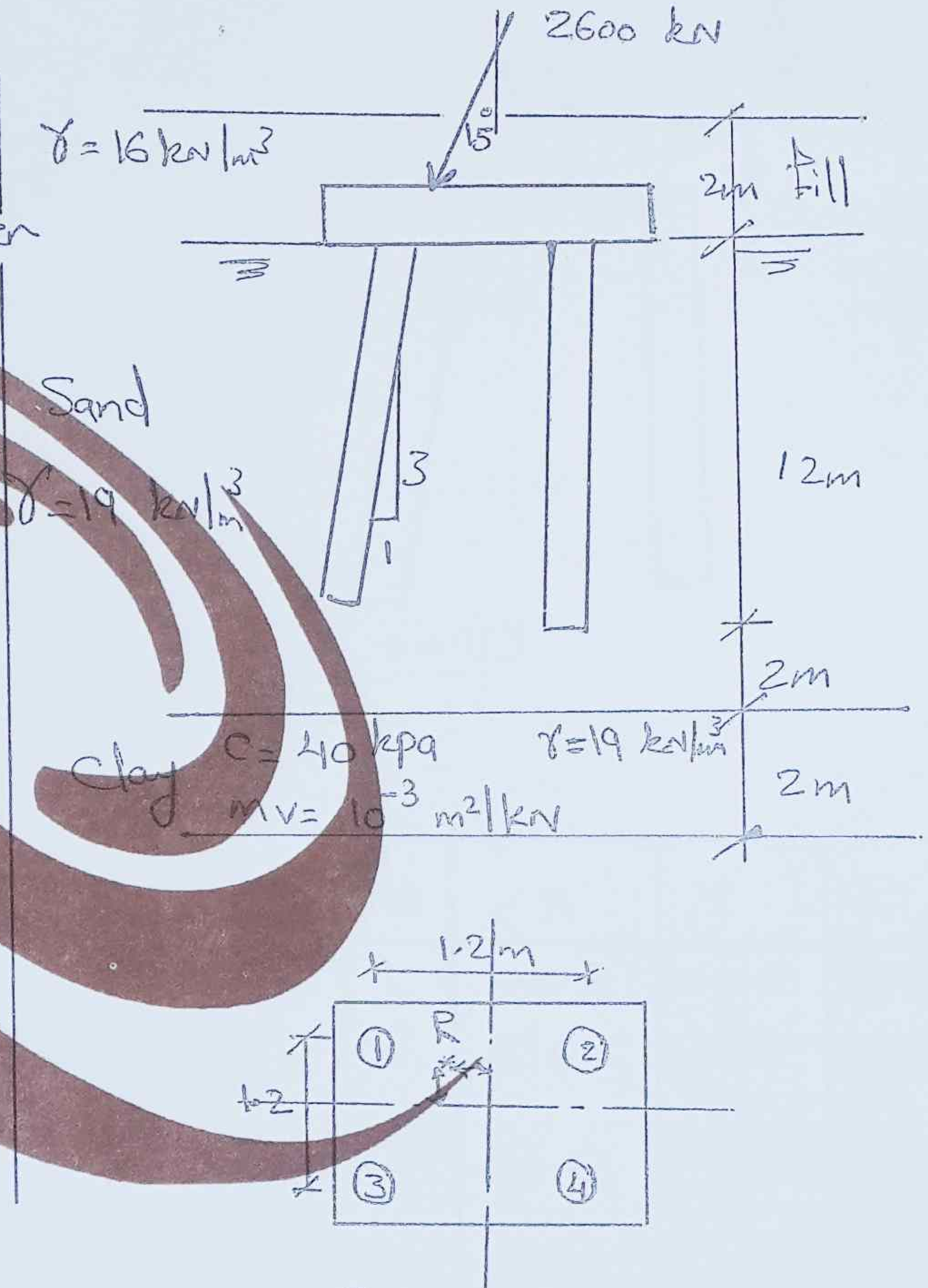
30 kN single acting hammer

1.3 m effective height

hammer makes 2cm / 4 blows

$C = 2.4$ cm

$\eta = 0.7$



Find :-

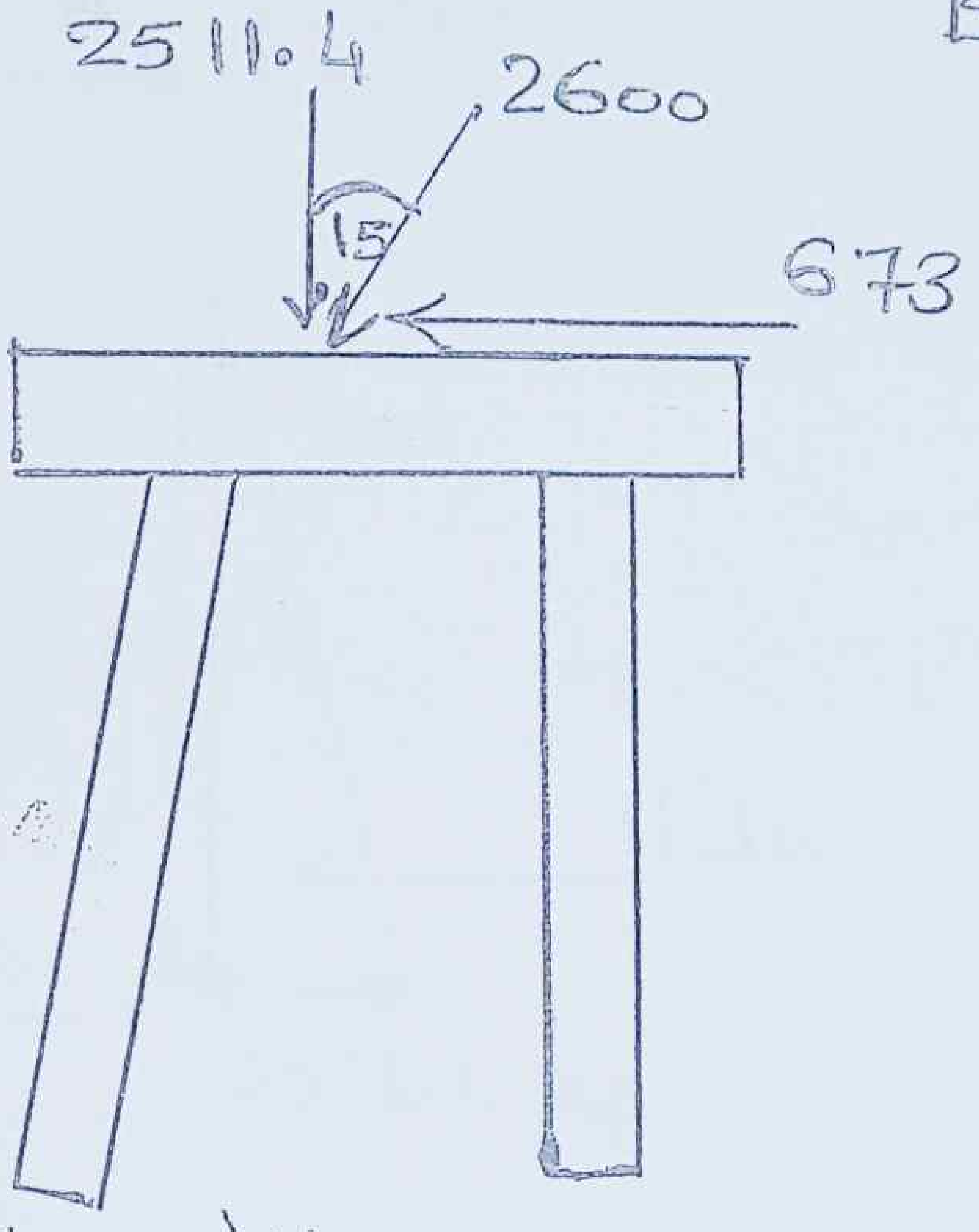
I Pile Capacity :-

$$R_u = \frac{W \times h \times \eta}{S + \frac{C}{2}}$$

$$= \frac{30 \times 1300 \times 0.7}{\frac{24}{2} + \frac{20 \text{ mm}}{4}} = 1605.9 \text{ kN}$$

$$R_{all} = \frac{1605.9}{3} = 535 \text{ kN}$$

[2] pile loading:-



$$P_v = \frac{V}{N} + \frac{V \cdot e_x \cdot x}{\sum x^2} + \frac{V \cdot e_y \cdot y}{\sum y^2}$$

$$\sum x^2 = 4 \times 0.6^2 = 1.44$$

$$\sum y^2 = 4 \times 0.6^2 = 1.44$$

$$P_v = \frac{2511.4}{4} + \frac{2511.4(-0.1)x}{1.44} + \frac{2511.4(+0.1)y}{1.44}$$

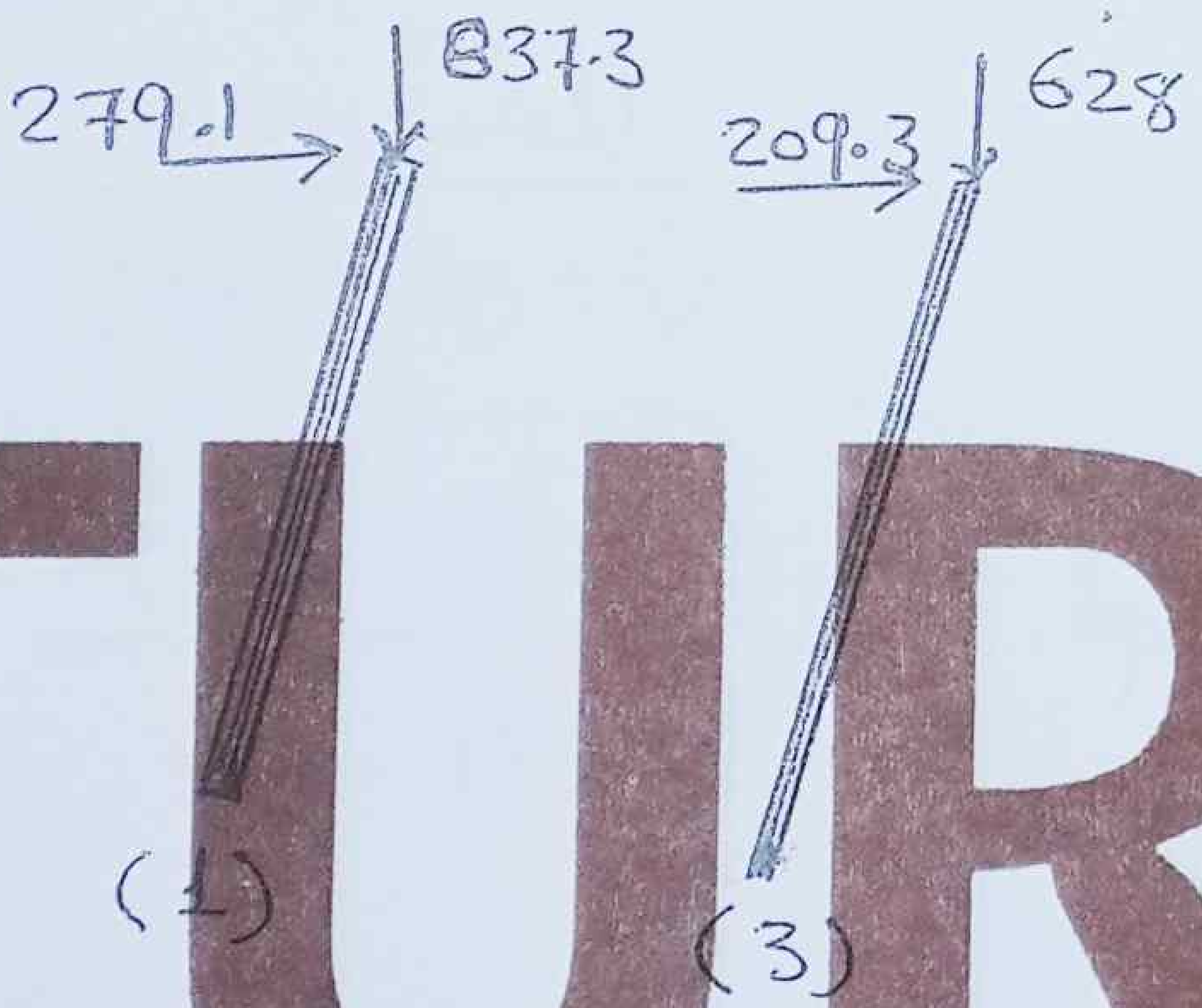
$$= 628 - 174.4x + 174.4y$$

Pile	x	y	Pv
1	-0.6	+0.6	837.3
2	0.6	0.6	628
3	-0.6	-0.6	628
4	0.6	-0.6	418.7

Rall < (piles 1, 2, 3)

* For Hl. loads:-

(1,3) بالنسبة للخوازيق المائلة



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$$\Delta H = 673 - (279.1 + 209.3) = 184.6 \text{ kN}$$

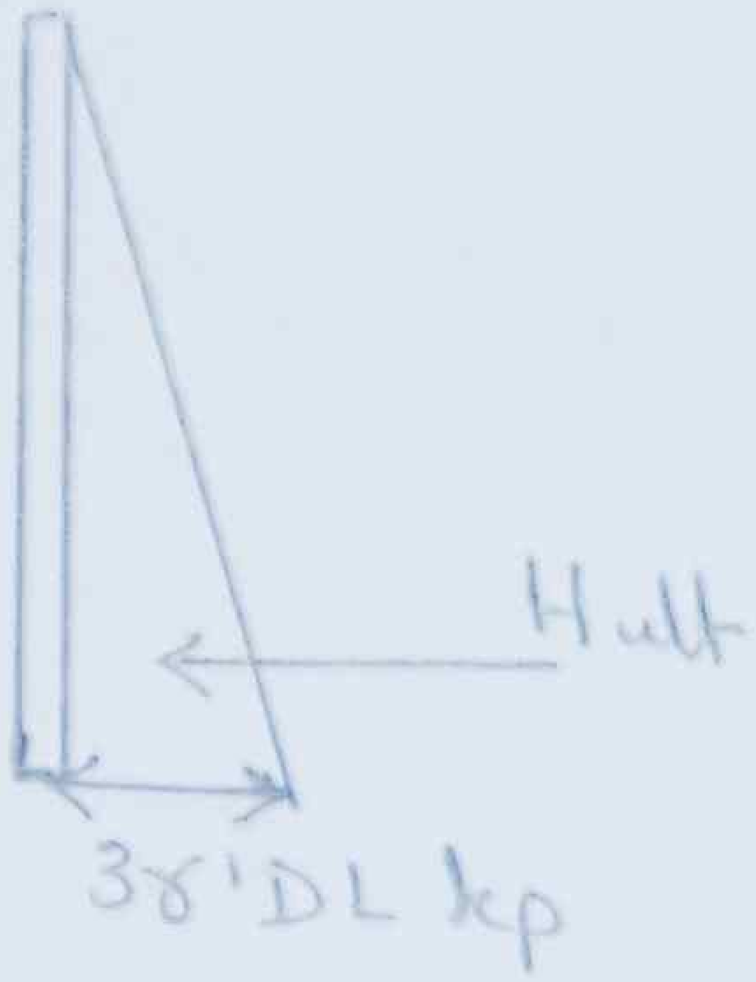
$$\Delta H / \text{pile} = 184.6 / 4 = 46.16 \text{ kN}$$

[3] Factor of safety against VL loading:-

$$F.S = \frac{16059}{837.3} = 1.92$$

4 Factor of safety against lat. loading :-

$$F.S = \frac{[illegible]}{[illegible]} = \frac{H_{ult}}{\Delta H}$$



Assume $\phi = 30^\circ$, $k_p = 3.0$

$$H_{ult} = \frac{1}{2} * (19-10) \times 0.4 \times (12)^2 \times 3$$

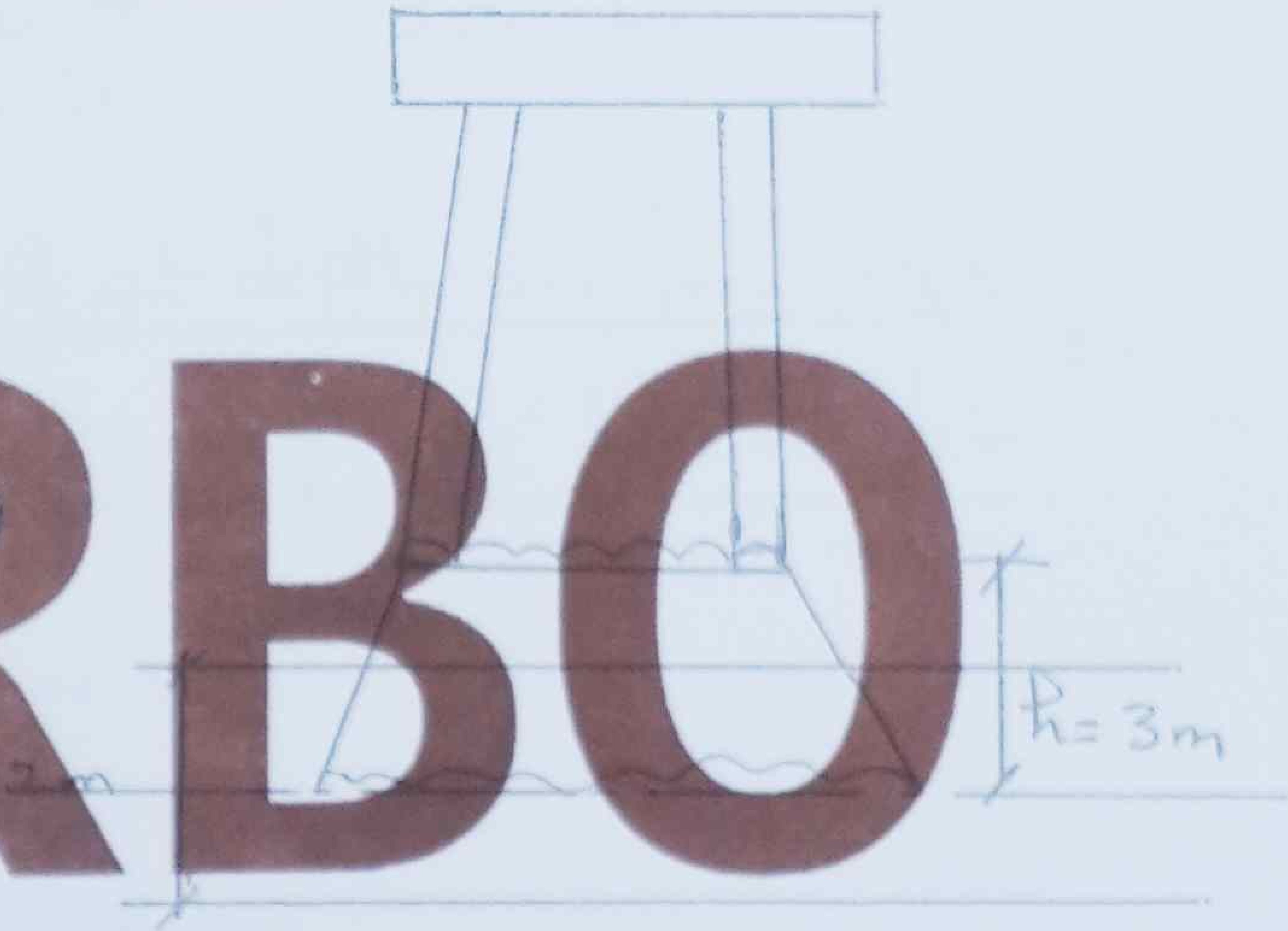
$$= 777.6 \text{ kN}$$

$$F.S = \frac{777.6}{46.16} = 16.8$$

5 Group settlement for end bearing piles :-

$$\delta = m_v \, \Delta\sigma \, H_c$$

$$\Delta\sigma = \frac{N \times Q_{all}}{(L_g + 3)(B_g + 3)}$$



$$= \frac{4 \times 535}{(1.6 + 3)^2} = 101.1 \text{ kpa}$$

$$\delta = 1 \times 10^{-3} \times 101.1 * 200$$

$$= 20.2 \text{ cm}$$

$L_g = 1.2 + 0.4 = 1.6\text{m}$

$B_g = 1.2 + 0.4 = 1.6\text{m}$

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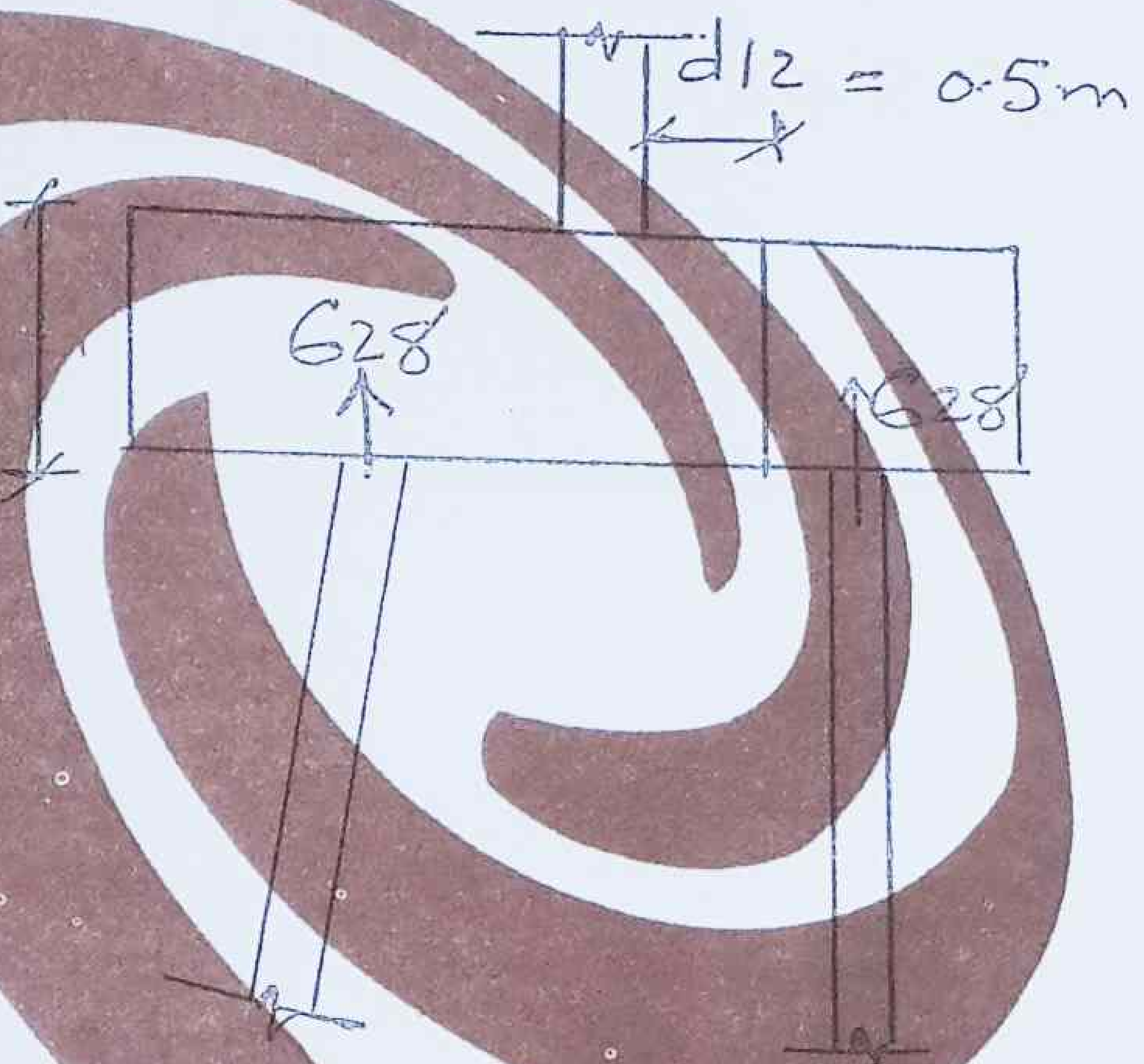
6 Assuming Cap thickness = 1m estimate shear stress on Critical section :-

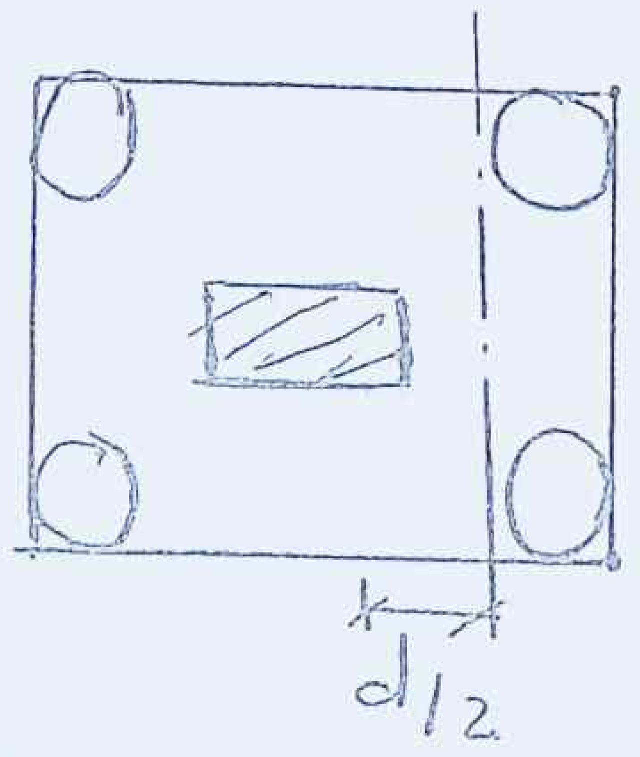
قطاع القص الحرج على مسافة $d/2$ من وجه العمود

$P_{pile} = \frac{2511.4}{4}$

$\simeq 628$ kN

ignore Cap wt.





$Q_{sh} = 2 * P_{pile} = 2 \times 628 = 1256$ kN

$q_{sh} = \frac{Q_{sh}}{B * d} = \frac{1256}{1.6 * 1.0} = 785$ kpa

7 if clay layer is found at depth 6m from G.S :- estimate load added to group due to -ve skin

الأقل { N * -ve skin for single pile
{ Per. * C * 0.7 L' + Ws

محيط الجروب Per. $= 2(L_g + B_g) = 6.4$m , $A_g = (1.6)^2 = 2.56$ m^2

TURBO

الأقل ⟹ $4 * C_a A_s = 4(0.9 \times 40) * \pi \times 0.4\,(0.7 \times 6)$ (with C_a written above 0.9 and $0.7L'$ above 0.7)

$= 760\ kN$

$(6.4 * 40 \times 0.7 \times 6) + 2.56 \times (2 \times 16 + 6 \times 0.7 \times 9)$ (with $0.7L'$ written above 6×0.7 and γ_{sub} above 9)

$= 1253.9\ kN$

TURBO

October 2005 :-

Pile load Test

P (kN)	0	450	900	1350	1800	2000
δ loading (mm)	0	3	5.6	10.2	16.5	38
δ unloading (mm)	25.4	29.2	31.8	34.4	37.8	38

$L = 18\,m$, $D = 0.5\,m$

Column load = 6000 kN

Req :- No. of pile arrangment

Sol. :-

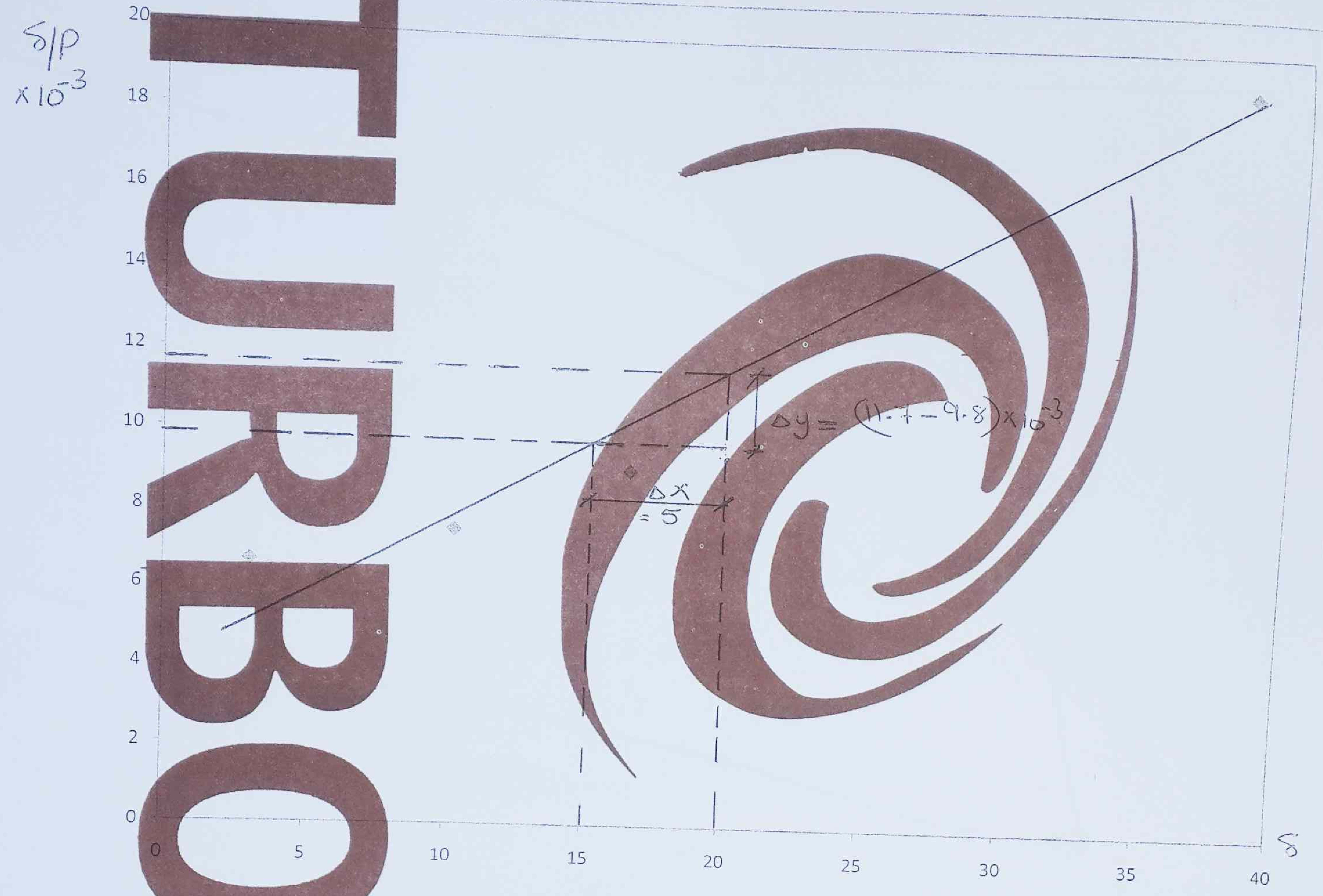
δ (mm)	-	3	5.6	10.2	16.5	38
$\delta/P \times 10^{-3}$	-	6.67	6.2	7.56	9.17	19

$$b = \frac{\Delta y}{\Delta x} = 3.8 \times 10^{-4} \longrightarrow Q_{ult} = \frac{1}{1.2b}$$

$$= \frac{1}{1.2 \times 3.8 \times 10^{-4}}$$

$$= 2192.98\ kN$$

$\therefore$ $Q_{ult} = 2192.98\ kN$


δ/P
x10^-3
20
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
δ
Δy = (11.7 − 9.8) x 10^-3
Δx = 5

25

0
500
1000
1500
2000
(load) kN
0
5
10
15
20
25
30
35
40
45
Settlement (δ)

26

بتطبيق الثلاث شروط :

[1] $Q_{ult} \geq 2\,Q_{all\,(D+L)}$

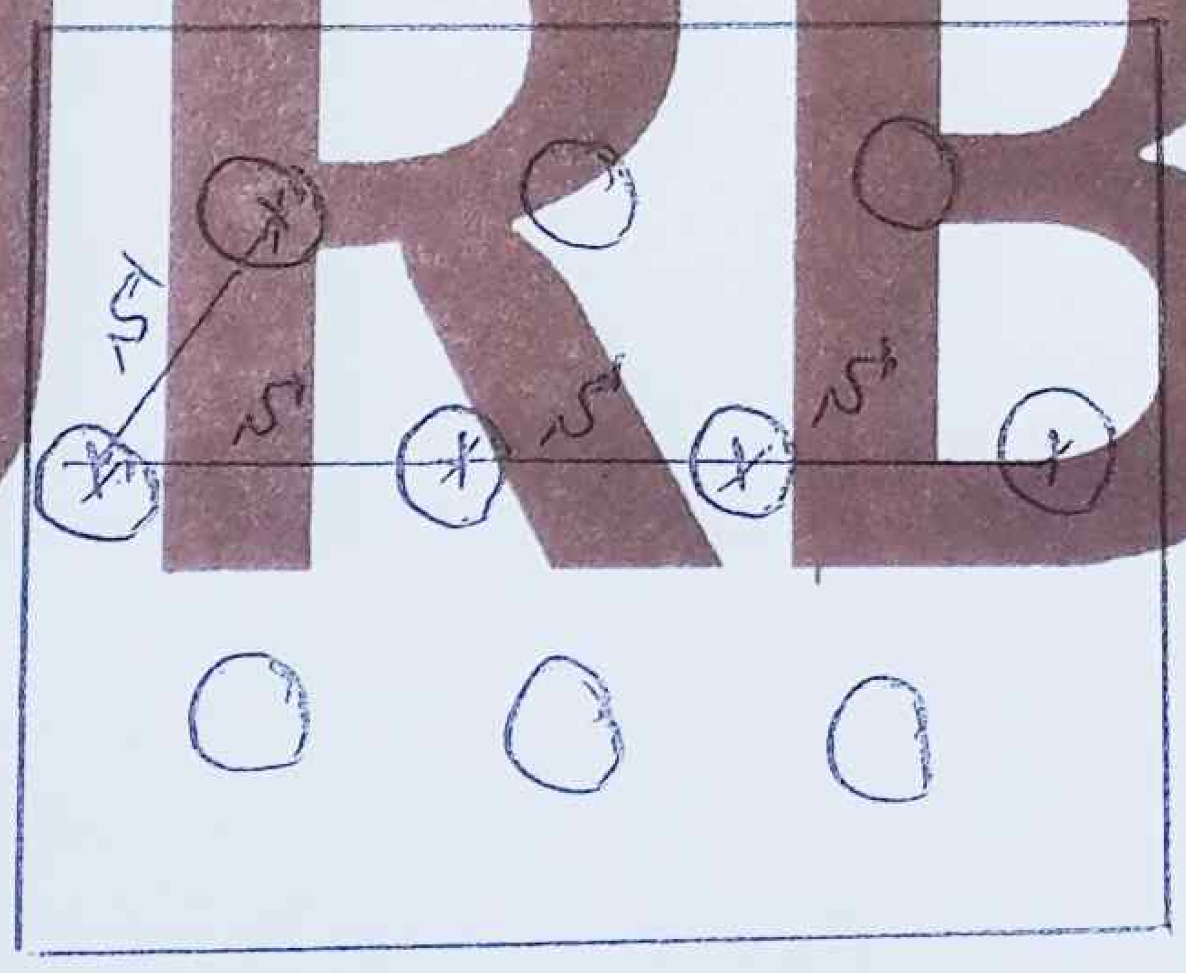
[2] $\dfrac{\delta \text{ at } 1.25\,Q_{all}}{\delta \text{ at } Q_{all}} \leq 1.5$

[3] $\delta \text{ at } (1.5\,Q_{all}) \leq \delta_{max}$

$\delta_{max} = 0.02D + 0.5\dfrac{PL}{EA}$

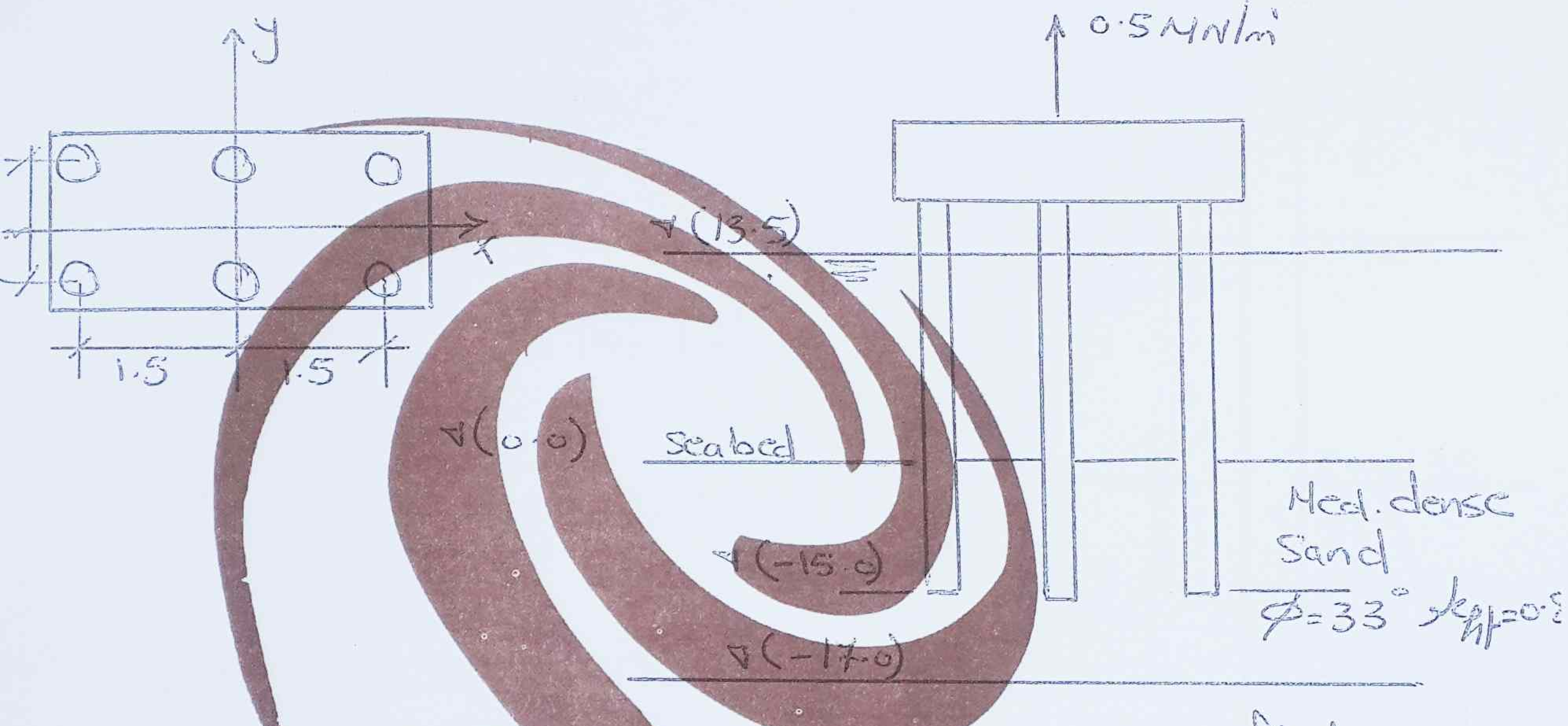
$\therefore\ Q_{all} = \dfrac{2192.98}{3.0} = 731\ kN$

$\therefore$ No. of piles $= \dfrac{1.1 \times 6000}{731} \simeq 10$ piles



Take S (2.5 → 8)d

May 2004 :-



Precast Concrete 40cm diam. piles   Soft clay

Req. :- the least Factor of Safety for These piles.

Sol. :-

(ملوش حل) $F.S = \frac{T_{ult}}{P_t}$

TURBO

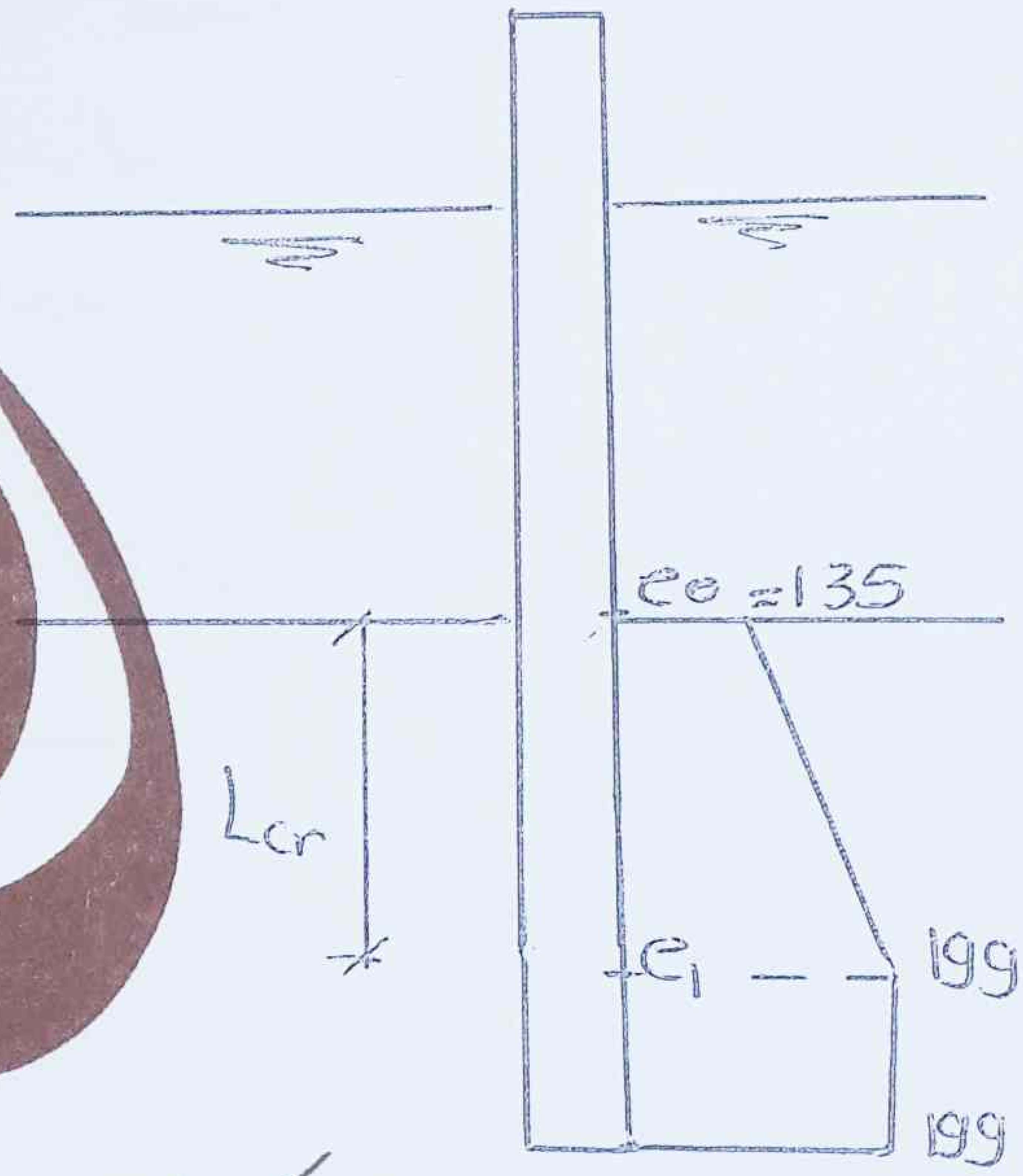
* Tension pile Capacity :

$$T_{ult} = Q_F + W_p$$

$$W_p = \overbrace{\frac{\pi}{4}(0.4)^2 \times 28.5}^{V} \times \overset{\gamma}{25} = 89.5 \text{ kN}$$

$Q_F = \sum K \pi r \times m \times \tan\delta \; \sigma'_z \; \Delta z$

$L_{cr} = 20 \times 0.4 = 8 \text{ m}$



$e_o = \gamma_w h_w$

$= 10 \times 13.5 = 135 \text{ kN/m}^2\text{/m}'$

مفروضة

$e_1 = 135 + (18 - 10) \times 8 = 199$

$\therefore Q_F = 0.8 \times \pi \times 0.4 \times \tan(\frac{3}{4} \times 33) \times$

$\left(\frac{135 + 199}{2} \times 8 + 199 \times 7\right) = 1264.8 \text{ kN}$

$\therefore T_{ult} = 1264.8 + 89.5 = 1354 \text{ kN}$

$\therefore T_{all} = \frac{1264.8 + 89.5}{3} = 511 \text{ kN}$

MN/m'   الطول

P_t (Tension load on each pile) $= \frac{0.5 \times 3}{6}$

$\therefore P_t = 0.25 \text{ MN} = 250 \text{ kN}$

$\therefore F.S = \frac{1354}{250} = 5.42$

→ How to increase the factor of safety in tension piles:

زيادة سعة الخازوق بزيادة طوله أو قطره و عدد الحلقات

إستخدام خوازيق (pipe) مفتوحة من أسفل وصب خرسانة بداخلها مما يؤدى إلى زيادة نهاية الخازوق (base enlargement)

مما يقاوم قوى الشد المؤثرة عليه.

May 2004:

Given: Hiley's Method

$C = 2.7$ cm (Contraction)

driving energy $= 40$ kN.m

$s' = 7$ mm

$e = 0.4$ (impact factor)

$W = 35$ kN

$P = 6$ kN (wt. of Cusions)

Req.: R_{all}.

Sol.:

$$R_u = \frac{W \times h \times \eta}{s' + \frac{C}{2}}$$

$(W \times h)$ = driving energy المقصود بـ
طاقة الطرقة.

To get η :- From chart (given)

P/W & $(e = 0.4)$ المعلومة

$$P = \text{wt. of pile} + \frac{\text{wt. of cusions} + \text{wt. of cap}}{6}$$

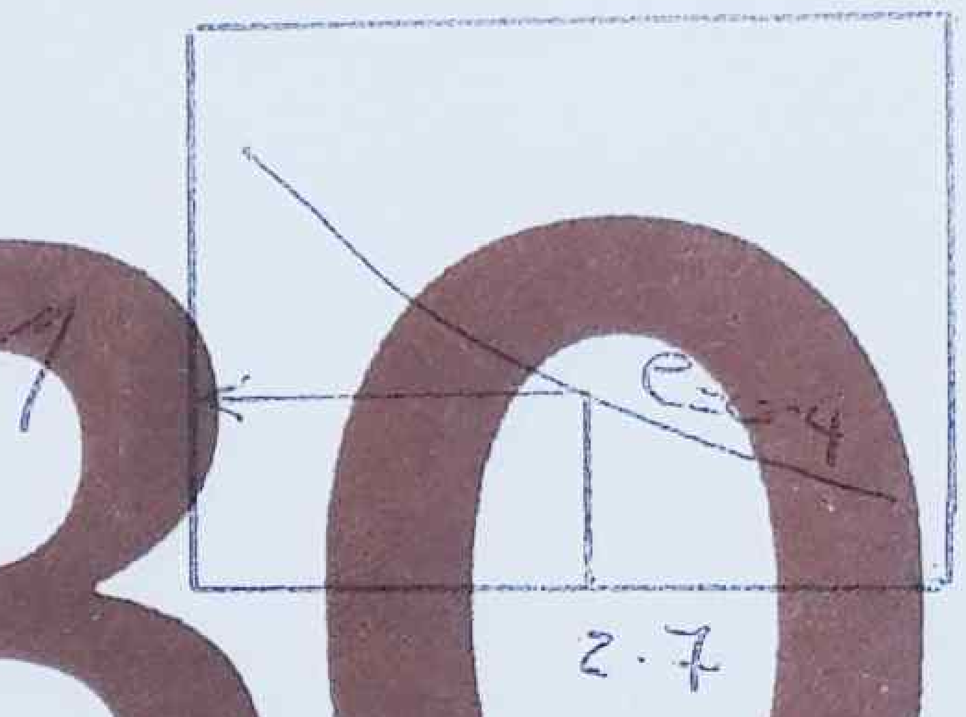
$(\gamma \star)$

$$= 89.5 + 6 = 95.5 \text{ kN}$$

↓ تم حسابه في مسائل سابقة

$$\therefore \frac{P}{W} = \frac{95.5}{35} = 2.7 \quad , \quad e = 0.4$$

$$\therefore \eta = 0.39$$



kN.m → kN.mm التحويل من

$$\therefore R_u = \frac{40 \times 1000 \times 0.39}{7 + \frac{2.7}{2}} = 761 \text{ kN}$$

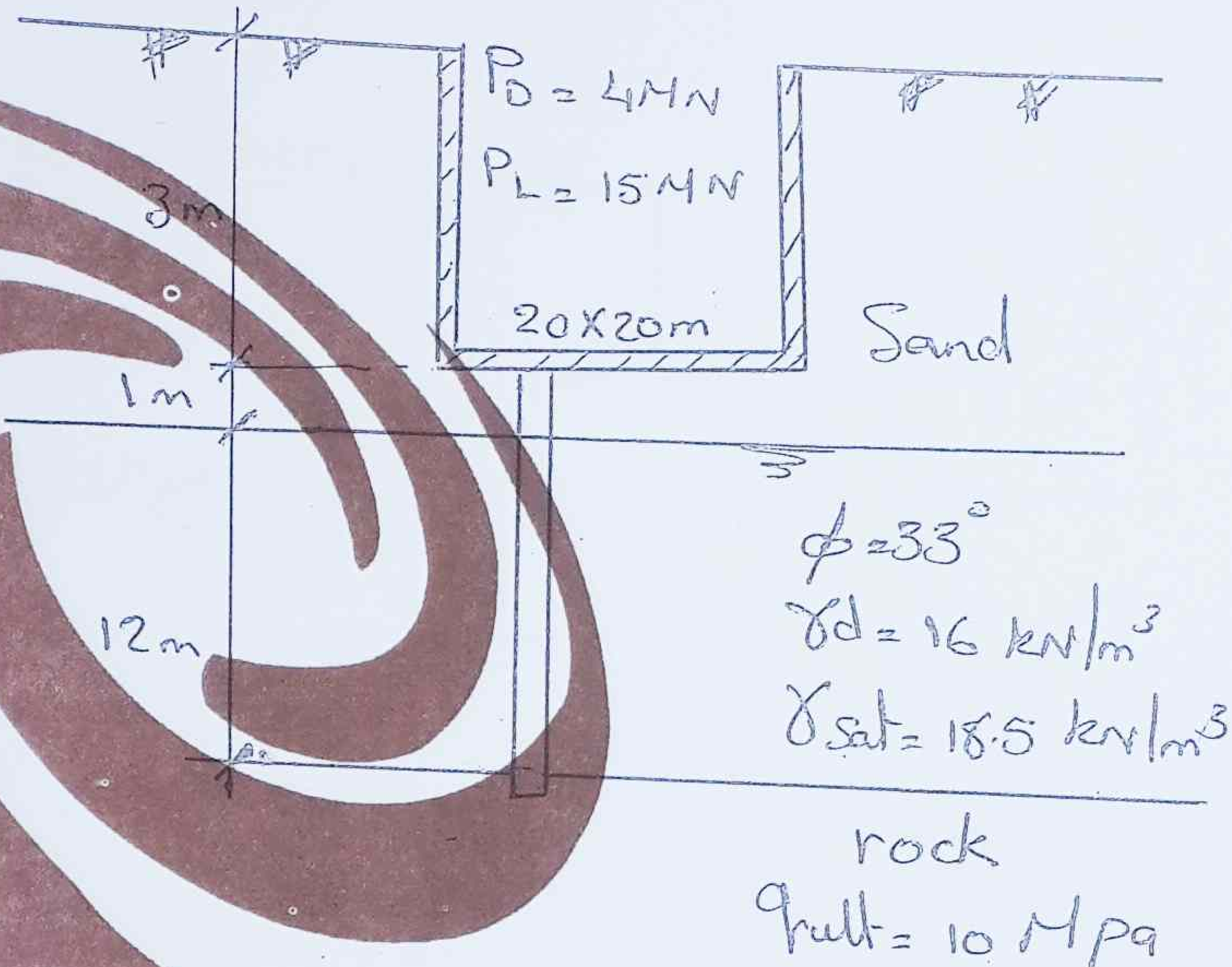
$$R_{all} = \frac{761}{3} = 253.6 \text{ kN.}$$

TURBO

Examples:-

Square Pile (driven)

B = 0.6m



Req.:-

for the underground water tank determine No. & arrangment of piles to Carry the tank.

TURBO

Sol.:-

$$Qult = Q_b + Q_F$$

* Bearing resistance:-

الارتكاز هنا في الصخر ومعطى اجهاد الارتكاز

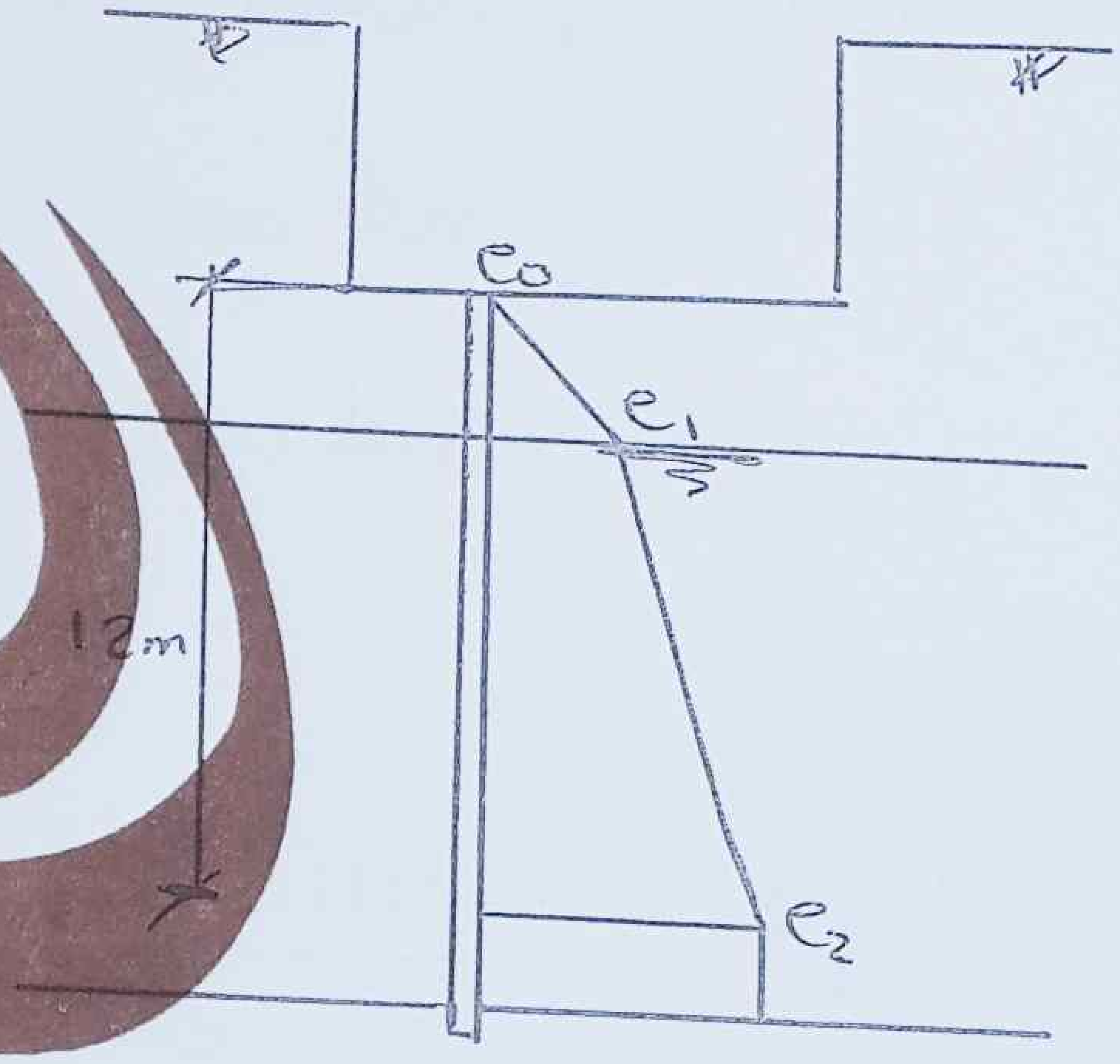
(حمل الارتكاز) Q_b = qult (اجهاد الارتكاز) × A_b (مساحة الارتكاز)

$$Q_b = 10 \times 1000 \times (0.6)^2 = 3600 \text{ kN}$$

(تحويل)

* **Frictional resistance:-**

ولما عمود التربة يكون بدايته عند أسفل الخزان وليس عند سطح الأرض



$L_{cr} = 20 \times d$

$= 20 \times 0.6 = 12 \text{ m}$

$e_0 = 0.0$

$e_1 = 16 \times 1 = 16 \text{ kN/m}^2$

$e_2 = 16 + (18.5 - 10) \times 11 = 109.5 \text{ kN/m}^2$

$$\therefore Q_F = \sum K_{hc} \; m \; \tan\delta \; e_z \; \Delta z$$

$$= 1.25 \times (4 \times 0.6) \times \tan\left(\frac{3}{4} \times 33\right) \times \left(\frac{1}{2} \times 16 \times 1 + \frac{16 + 109.5}{2} \times 11 + 109.5 \times 1\right) = 1117.1 \text{ kN}$$

$$\therefore Q_{ult} = 3600 + 1117.1 = 4717.1 \text{ kN}$$

$$Q_{all} = \frac{4717.1}{3} = 1572 \text{ kN}$$

TURBO

وتكمن ما احدث فعليا هو ان هذا الخازوق مرتكز على الصخر وبالتالي هو خازوق ارتكاز ولعدم حدوث حركة للخازوق فان التربة لن تقاوم بالاحتكاك ولن يكون كذلك.

$$\therefore Q_{ult} = Q_b = 3600\ kN$$

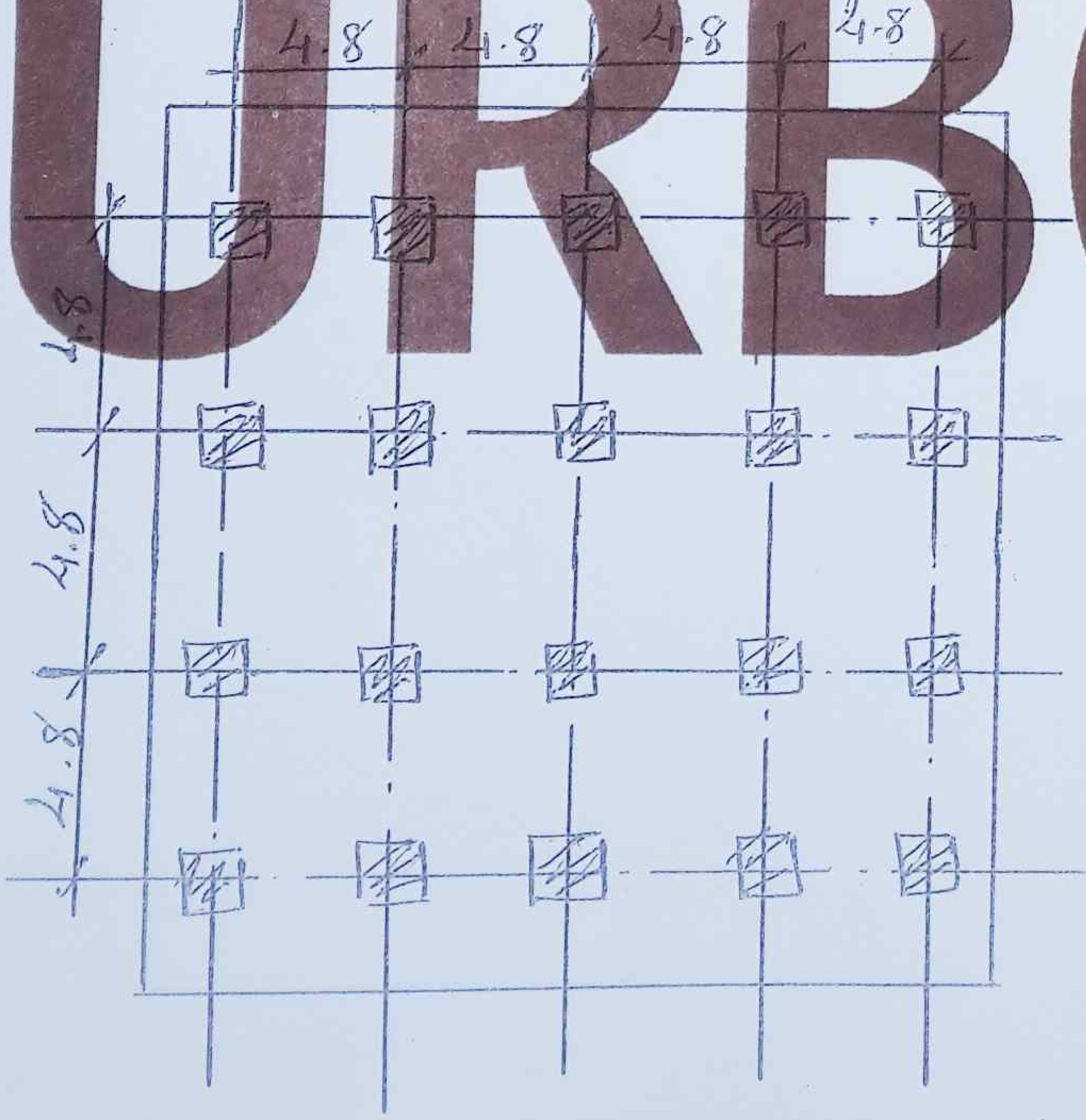
$$Q_{all} = \frac{3600}{3} = 1200\ kN$$

$$\text{No. of piles} = \frac{(4+15)\times 1000}{1200} \simeq 18\ \text{piles}$$

$$S = (3 \rightarrow 8)d \simeq (1.8 \rightarrow 4.8\ m)$$

ثم اخذ عدد الخوازيق (٢٠) لتسهيل ترتيب الخوازيق $(S = 4.8m)$

لان مساحة الخزان كبيرة.



ملحوظة هامة:-

إذا ذكر في المسألة ان الحفر تم باستخدام نفاثات المياه

water jetting يهمل الاحتكاك تماماً حتى الأعماق التي

وصلتها نفاثات المياه.

May 2001 :-

9 m Square pile , B = 40 cm

elev. (m)	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14 to end
Soil Type	loose sand $\phi = 25^\circ$, $\gamma_{sat} = 17\ kN/m^3$, G.W.T at -3m							Med. dense $\phi = 31^\circ$, $\gamma = 19$				Med. stiff clay $\gamma = 19$		Sand $\gamma = 19.5\ kN/m^3$
SPT	5	6	7	7	9	8	10	11	12	15	14	11	10	13
q_c (Mpa)	2	3	4	2	2.5	2	3	5	6	7.5	6	7	6.5	9
f_c (kpa)	10	12	15	16	17	20	25	25	32	35	40	30	33	40

determine Qall , Qult using field investigation.

Sol. :-

1- using SPT :-

$$Q_{all} = 90\ N\ A_b + N'\ A_s$$

$$6r = 6 \times 0.2 = 1.2\ m$$
$$2r = 0.4\ m$$

$$N = \frac{11 + 12 + 15}{3} = 12$$

$$N' = \frac{5 + 6 + 7 + 7 + 9 + 8 + 10 + 11 + 12}{9} = 8$$

$$\therefore Q_{all} = 90 \times 12 \times (0.4)^2 + 8 \times 4 \times 0.4 \times 9 = 288\ kN$$

$$= 172.8 + 115.2 = 288\ kN$$

TURBO

$Q_{ult} = 2.5 \times 172.8 + 2 \times 115.2 = 662.4$ kN.

2- <u>Using CPT :-</u>

$$Q_{all} = \frac{1}{3} \alpha q_c A_b + \frac{1}{2} f_c A_s$$

$$q_c = \frac{3+5+6+7.5+6}{5}$$

$= 5.5$ Mpa $= 5.5 \times 1000$ kpa

$= 55$ kg/cm² < 150 kg/cm²

$6D = 6 \times 0.4 = 2.4$ m

$3D = 3 \times 0.4 = 1.2$ m

$$f_c = \frac{10+12+15+16+17+20+25+25+32}{9} = 19.1 \text{ kpa}$$

$= 0.19$ kg/cm² < 1 kg/cm²

$$Q_{all} = \left(\frac{1}{3} \times 0.7 \times 5.5 \times 1000 \times (0.4)^2\right) + \left(\frac{1}{2} \times 0.19 \times 4 \times 0.4 \times 9\right)$$

$= 205.3 + 137.5 = 342.8$ kN

$Q_{ult} = 205.3 \times 3 + 137.5 \times 2 = 890.9$ kN

وبالتالي يتم اخذ متوسط الطريقتين

$$Q_{all} = \frac{342.8 + 288}{2} = 315.4 \ kN$$

$$Q_{ult} = \frac{662.4 + 890.9}{2} = 776.6 \ kN$$

ملحوظة هامة :

إذا لم نُعطى قيم للإحتكاك في اختبار (CPT) يتم اخذ

$$f_c = 0.005 \ q_c$$

TURBO

* اذا كان الخازوق سيتحمل أحمال شد وطلب التصميم

بطريقة SPT و CPT :-

1- SPT :-

في كل الأحوال لا يوجد ارتكاز

$$T_{all} = N A_s + W_{pile}$$

2- CPT :-

$$T_{all} = \frac{1}{2} f_c A_s + W_{pile}$$

مثال: إذا افترضنا في المسألة السابقة ان الخازوق يتحمل الشد

SPT :-

$$T_{all} = 115.2 + (\overset{\gamma}{25} \times \overset{A}{(0.4)^2} \times \overset{L}{9})$$

$$= 115.2 + 36 = 151.2 \text{ kN}$$

CPT :-

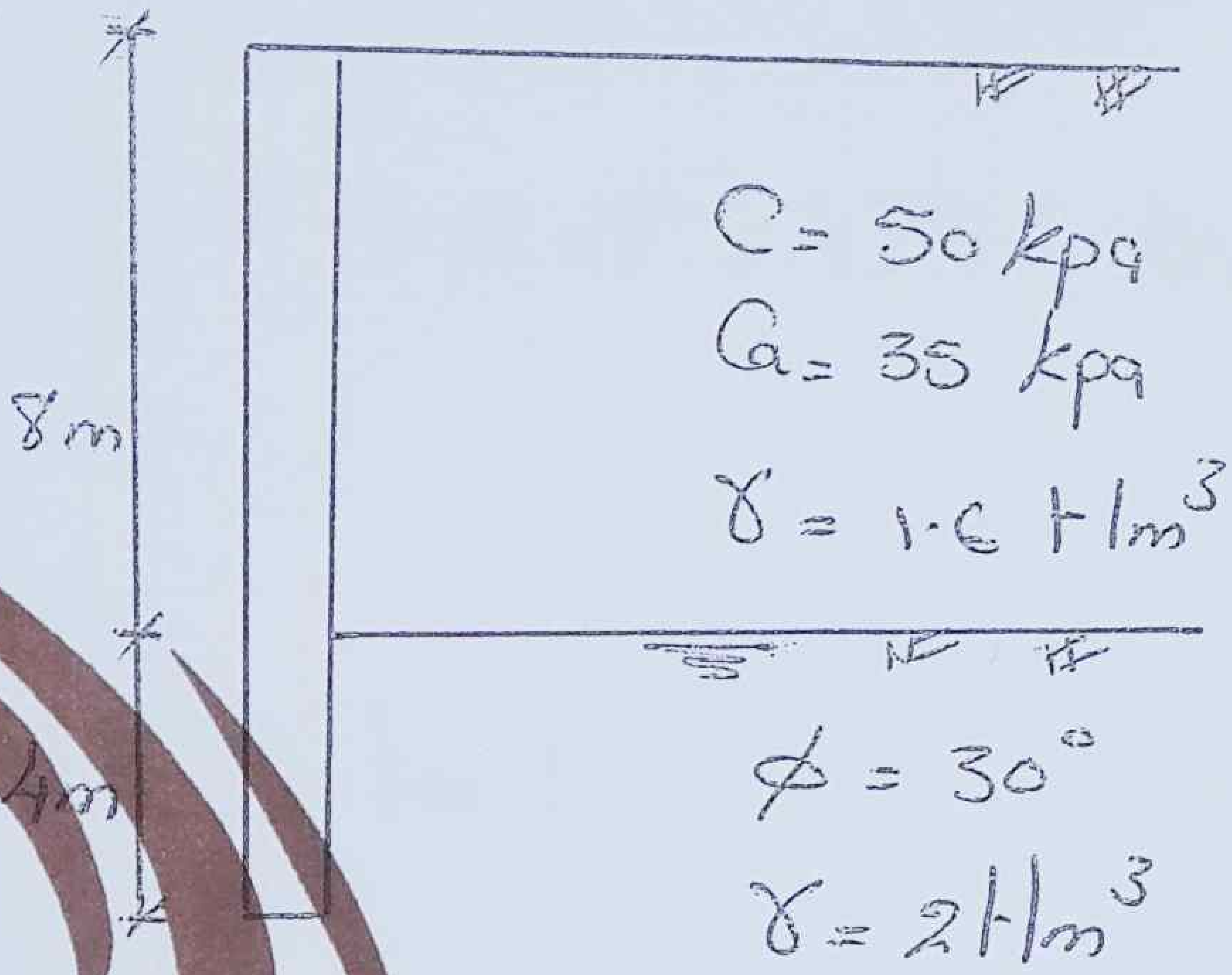
$$T_{all} = 137.5 + 36 = 173.5 \text{ kN}$$

Example :-

D = 0.5 m , Driven Concrete pile

Req :- 1) allowable Capacity

2) embeded depth in Sand to satisfy Tension load = 300 kN



Sol. :-

1- allowable pile Capacity :-

$Q_{ult} = Q_b + Q_F$

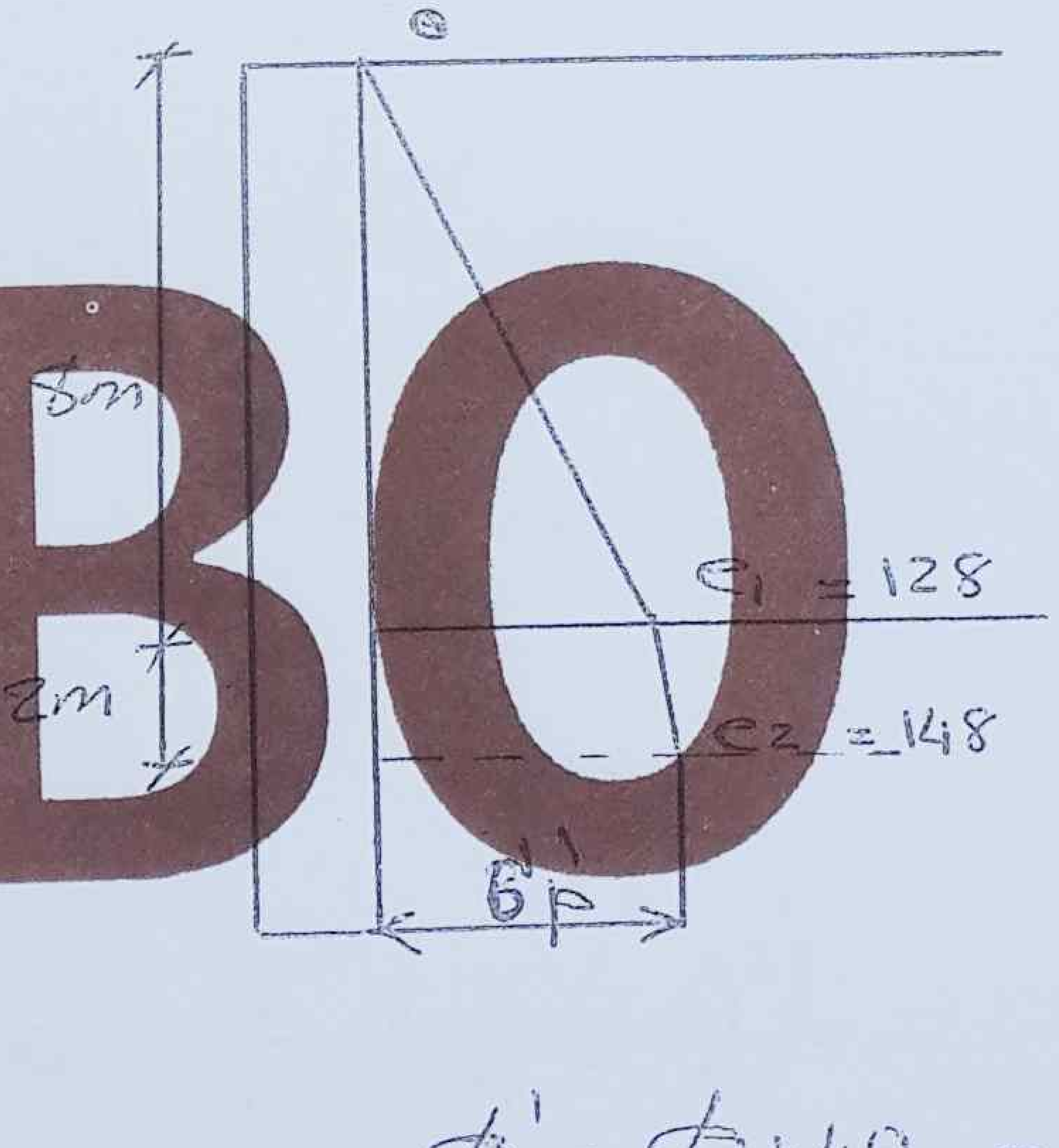
* bearing resistance :-

$Z_{cr} = 20 \times d = 10\ m$

$\sigma_1 = 16 \times 8 = 128\ kpa$

$\sigma_2 = 128 + (20 - 10) \times 2$

$= 148\ kpa$



$Q_b = \sigma'_p \times N_q \times A_b$

$\phi' = \frac{\phi + 40}{2} = 35°$

$N_q = 75$

$= 148 \times 75 \times \frac{\pi}{4} (0.5)^2$

$= 2179.5\ kN$

* Friction resistance :-

clay :- $Q_{Fc} = C_a A_s$

$= 35 \times \pi \times 0.5 \times 8 = 439.8 \text{ kN}$

Sand :-

$Q_{Fs} = \sum k_{Hc} \times P \times \Delta z \times m \times \tan \delta$

$= 1.0 \left(\frac{128 + 148}{2} \times 2 + 148 \times 2 \right) \times \pi \times 0.5$

$\times \tan \left(\frac{3}{4} \times 30 \right) = 282.4 \text{ kN}$

$Q_F = 282.4 + 439.8 = 722.18 \text{ kN}$

$\therefore Q_{ult} = 722.18 + 2179.5 = 2901.7 \text{ kN}$

$Q_{all} = \frac{2901.7}{3.0} = 967.2 \text{ kN}$

TURBO

* Concrete Capacity :- لعمود الخرسانة

$Q_p = F_c (A_c + 1.14 \times 10 \times A_s)$

$= 500 \left(\frac{\pi}{4} (0.5)^2 + 1.14 \times 10 \times \frac{1}{100} \times \frac{\pi}{4} (0.5)^2 \right) =$

$= 109.4 \text{ ton}$

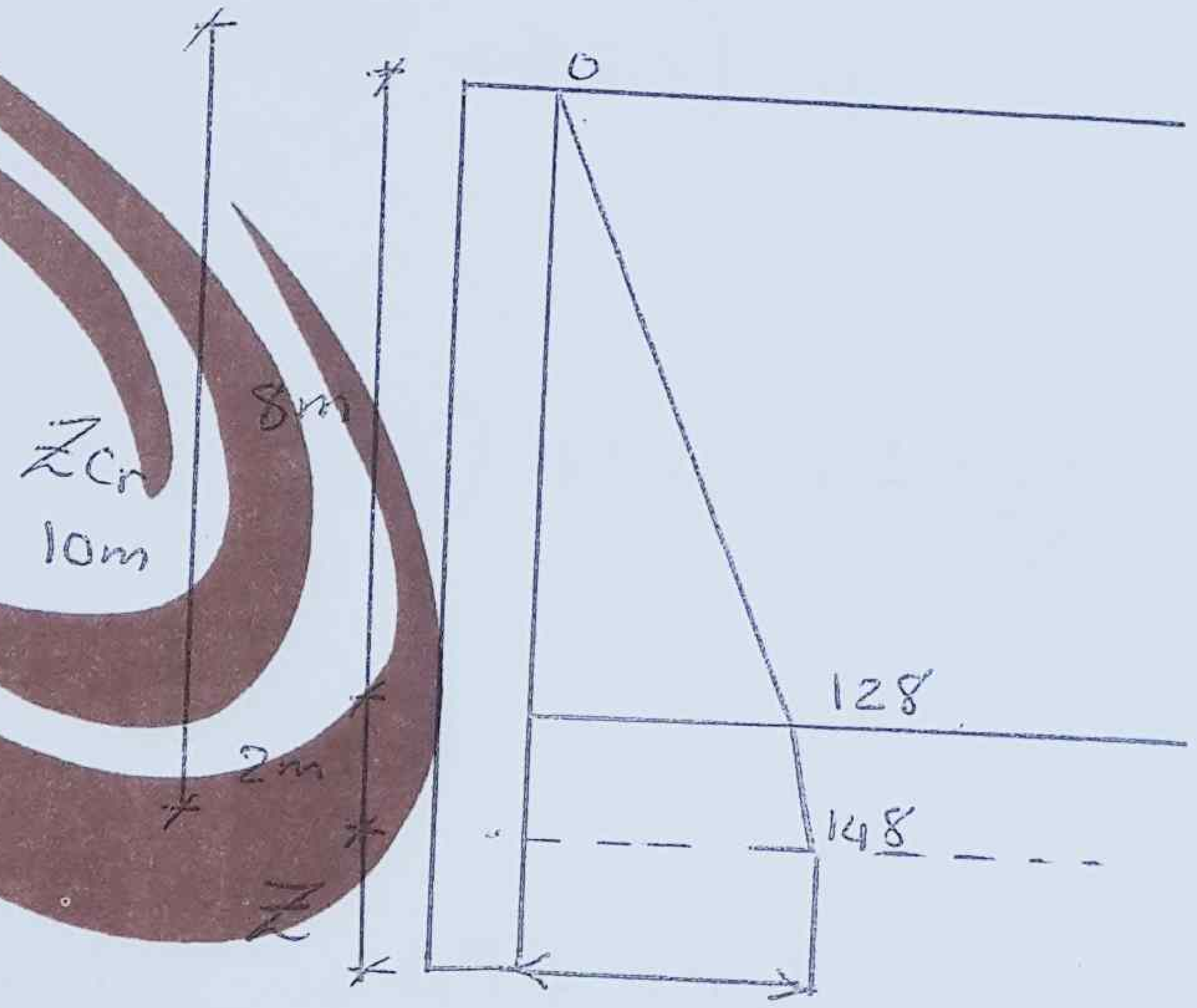
$= 1094 \text{ kN}$

2- embeded Length in Sand:

المطلوب طول الخازوق المدفون في الرمل لكي يقاوم حمل شد مقداره ٣٠٠ كن

$$T_{all} = \frac{Q_F}{3} + W_p$$

$(2+Z)$ = طول الخازوق في الرمل



$$W_p = \frac{\pi}{4} \times (0.5)^2 \times (10+Z) \times 25 = 49 + 4.9Z$$

* Friction resistance:

Sand:- $Q_{F_s} = \Sigma K_{Ht} \times P \times \Delta Z \times m \times \tan\delta$

$$= 0.8\left(\frac{128+148}{2} \times 2 + 148 \times Z\right) \times \pi \times 0.5$$

$$\times \tan\left(\frac{3}{4} \times 30\right) = 0.52\,(276 + 148Z)$$

$$Q_{Fs} = 143.52 + 76.96Z$$

clay:- $Q_{Fc} = C_a\, A_s$

Take $C_a = 0.8 \times 35 = 28$ kpa

وذلك لتقليل (Ca) في حالة الشد

$Q_{Fc} = 28 \times \pi \times 0.5 \times 8 = 351.8 \text{ kN}$

$\therefore T_{ult} = Q_F + W_p$

$= (143.52 + 76.96 Z + 351.8) + (49 + 4.9 Z)$

$= (495.4 + 76.96 Z) + (49 + 4.9 Z)$

$T_{all} = \frac{Q_F}{3.0} + W_p = 300$

$300 = 165.1 + 25.65 Z + 49 + 4.9 Z$

$300 = 214.1 + 30.55 Z$

$\therefore Z = 2.81 \text{ m}$

$\therefore$ embeded Length $= 2 + 2.81 = \underline{\underline{4.81 \text{ m}}}$

إذا كانت (Z) سالبة لقيمة الجذر فرضنا خطأ انا لم نحتاج لطول خازوق في الرمل.

TURBO